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Horiko

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(54) **MUFFLER**

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F01N 1/16 (2006.01)
F01N 1/18 (2006.01)
F02M 35/00 (2006.01)

(52) **U.S. Cl.** **181/250**; 181/266; 181/273; 181/276; 181/249; 181/255; 181/269; 123/184.53; 123/184.54; 123/184.55; 123/184.56; 123/184.57

(58) **Field of Classification Search** 181/250, 181/266, 273, 276, 249, 255, 269; 123/184.53, 123/184.54, 184.55, 184.56, 184.57
See application file for complete search history.

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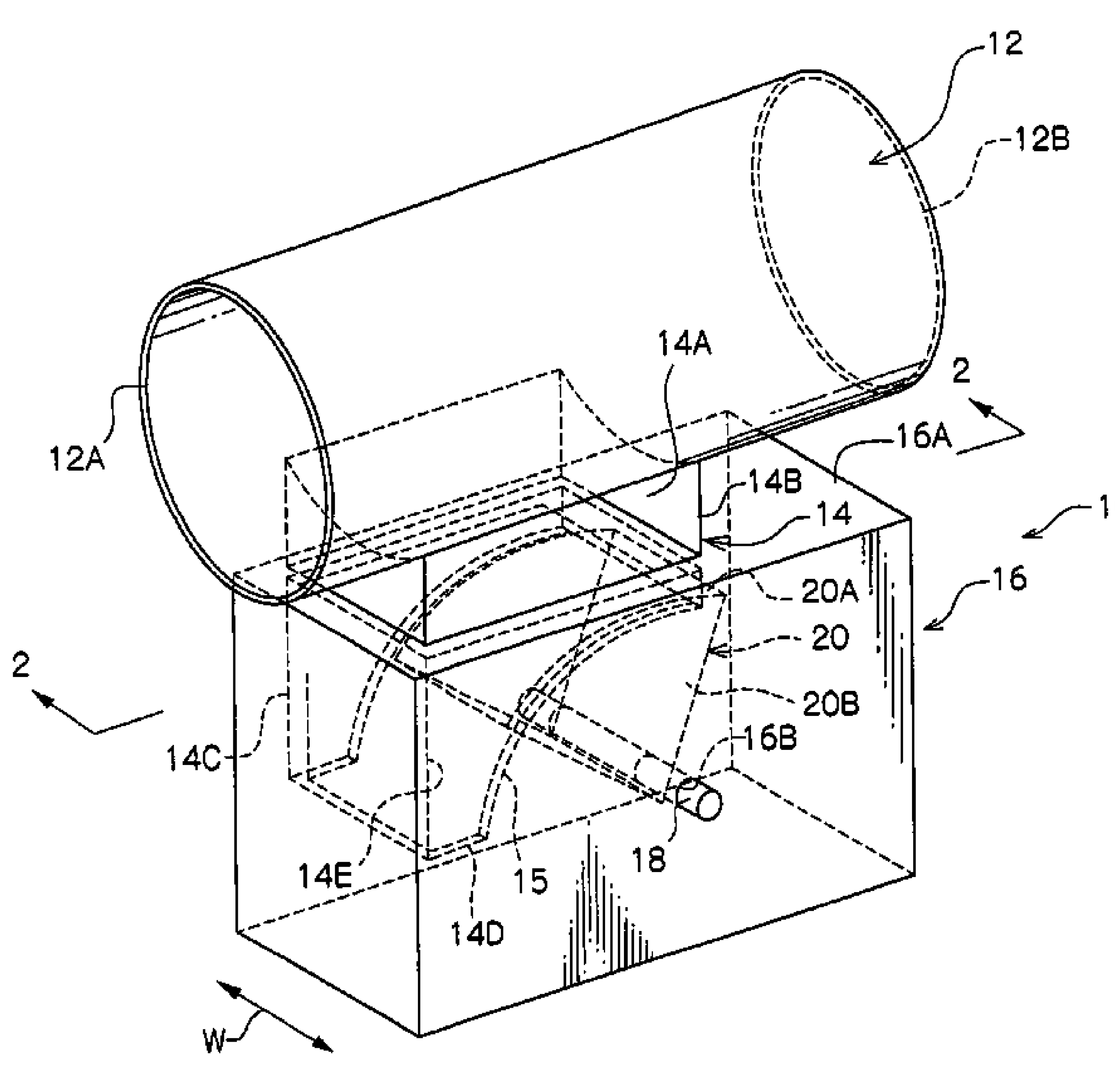
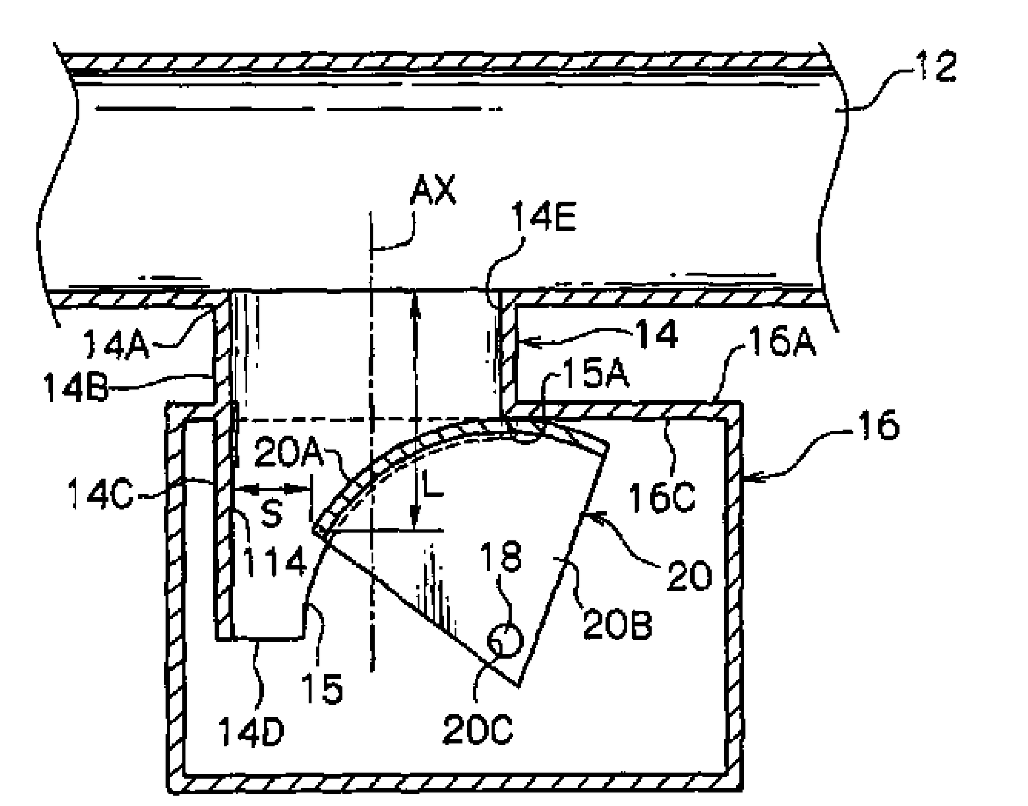
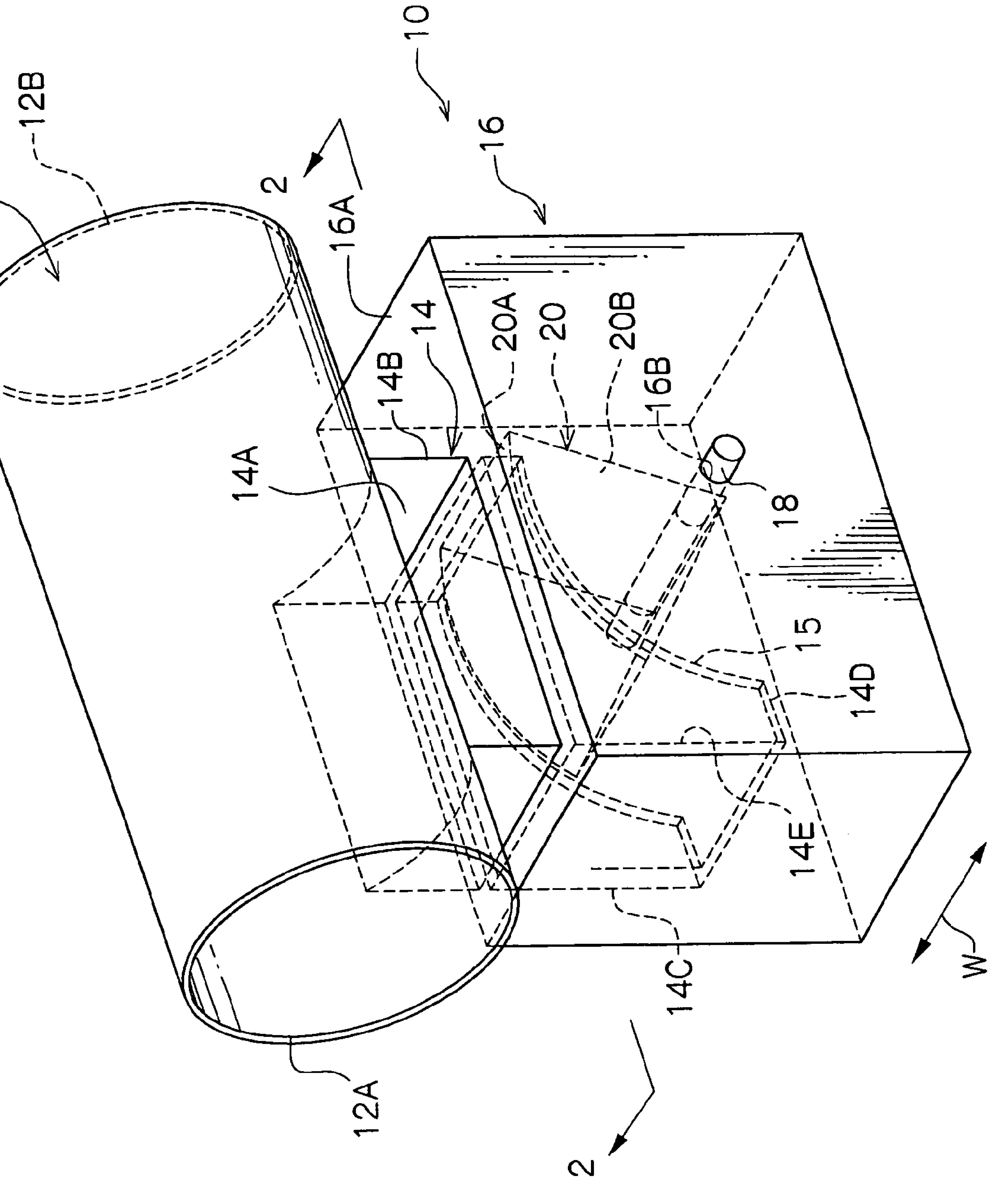
(57) **ABSTRACT**

A muffler which reduces noises of a wide frequency band with a simple structure. Sound waves of an intake duct enter into and are received in a resonance box via a branch pipe. At the branch pipe, a movable body slidingly abuts a peripheral portion of an opening of a cut-out portion. Due to the movable body rotating, a range of opening/closing of the cut-out portion is changed, and a length of a neck portion formed by the branch pipe and an arc-shaped plate, and a lateral cross-sectional surface area of a distal end of the neck portion, are changed.

15 Claims, 16 Drawing Sheets







12
12B
2
10
16
16A
14
14B
14A
20A
20
20B
16B
18
15
14D
14E
14C
W
12A
2

FIG.1

FIG.2

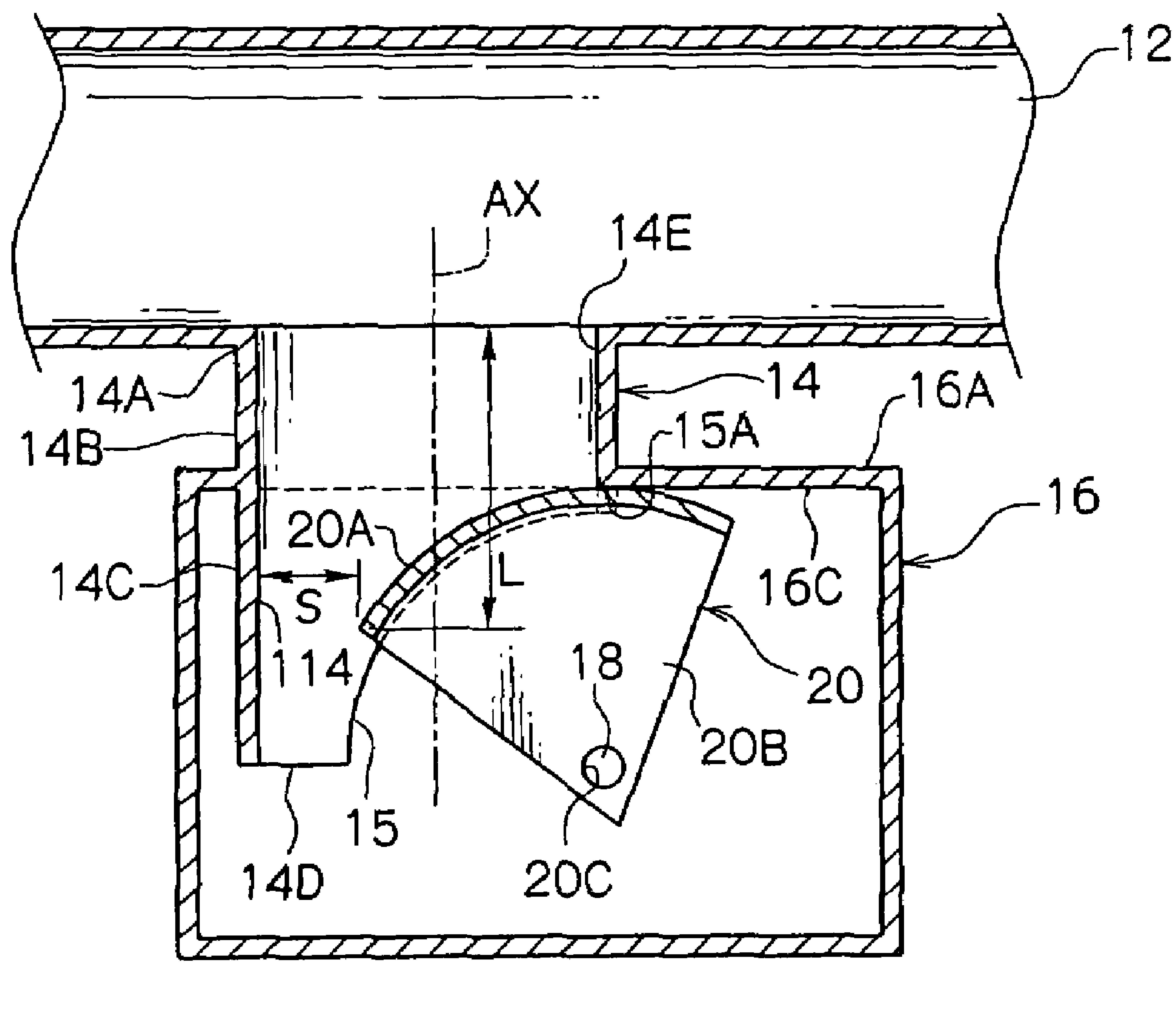
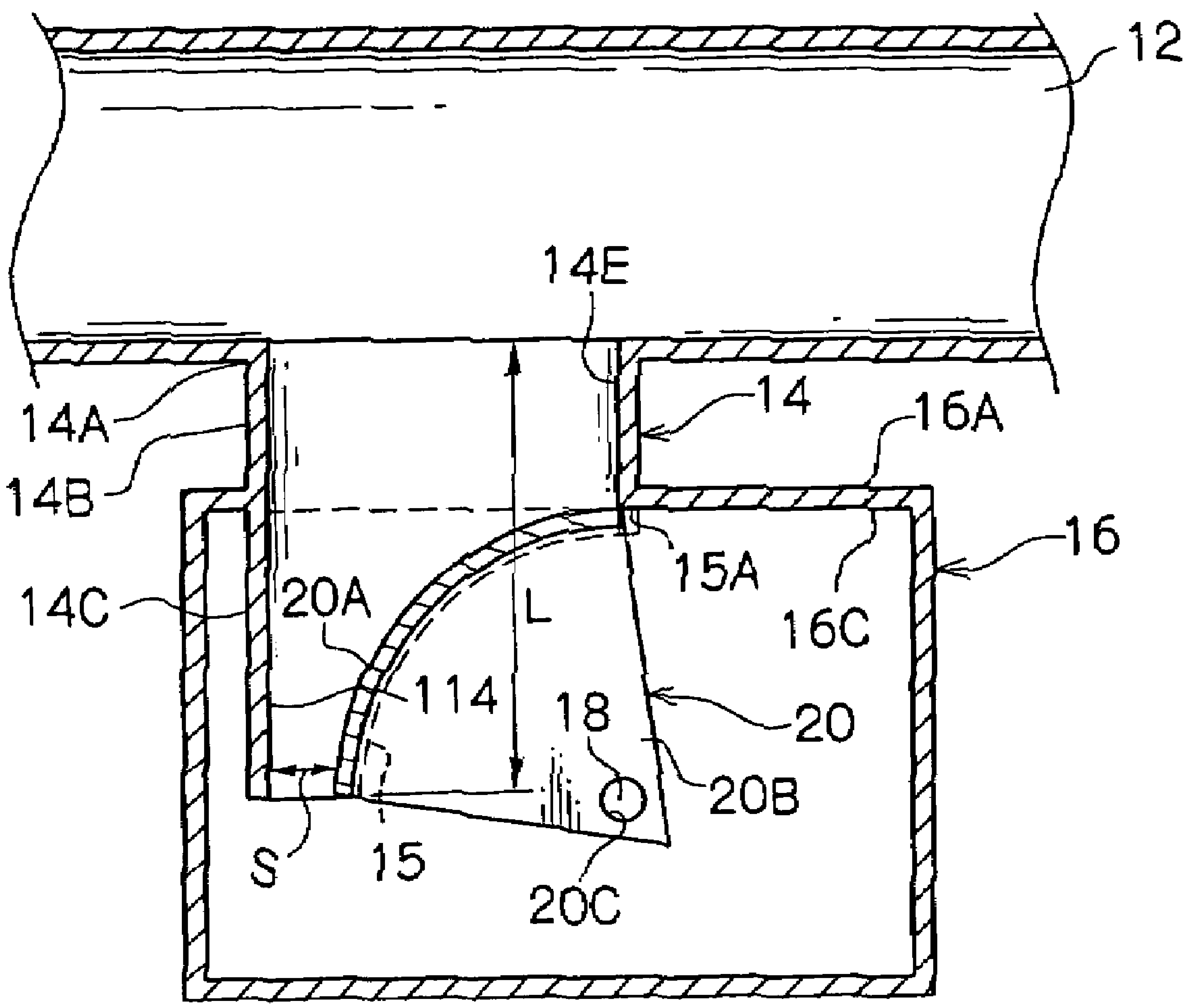

12
AX
14E
14A
14
16A
14B
15A
16
20A
L
14C
S
16C
114
18
20
20B
15
20C
14D

FIG.3



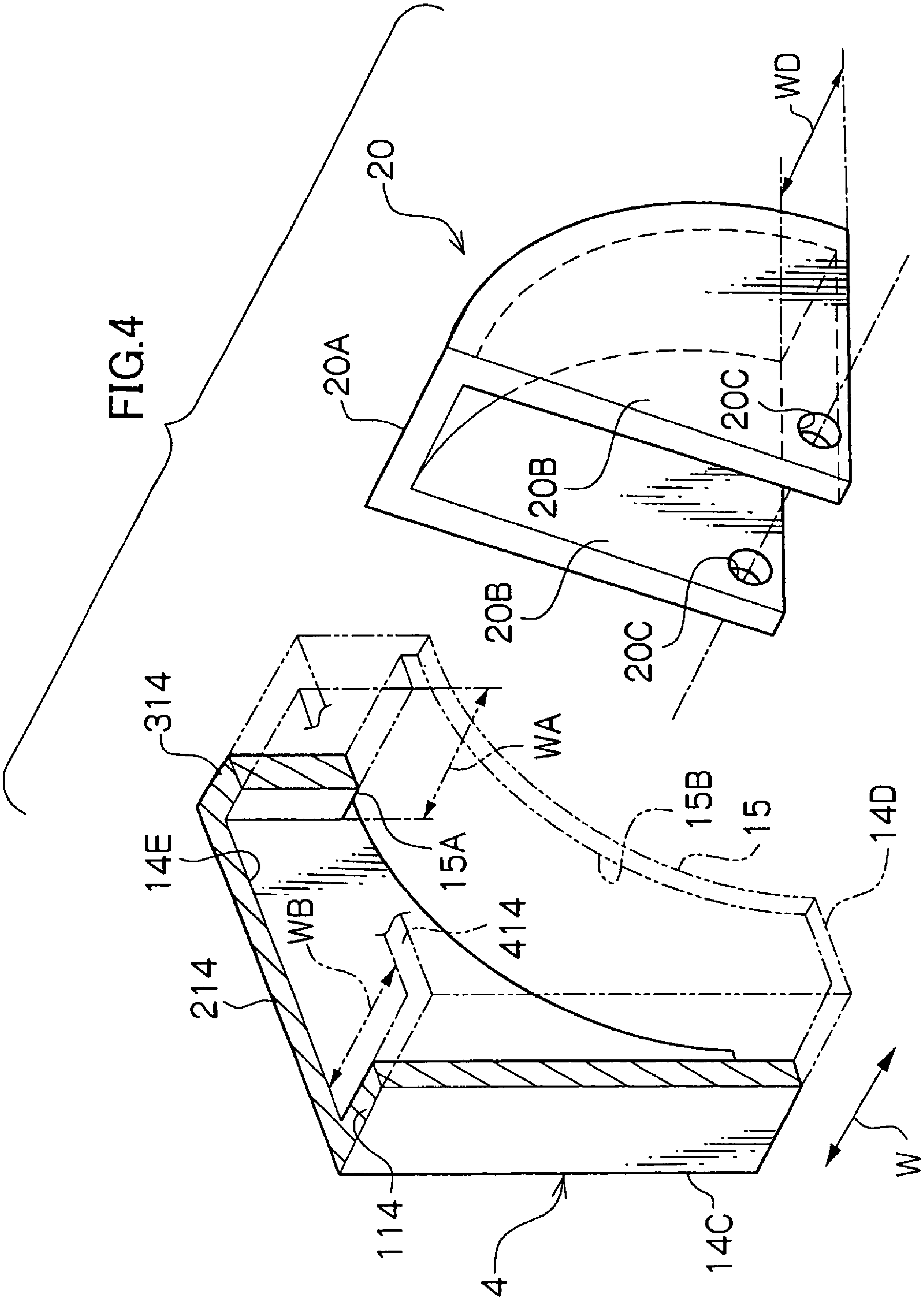

20
WD
20A
20B
20B
20C
20C
314
WA
15B
15
14D
14E
15A
414
WB
214
114
14
14C
W

FIG.4

FIG.5

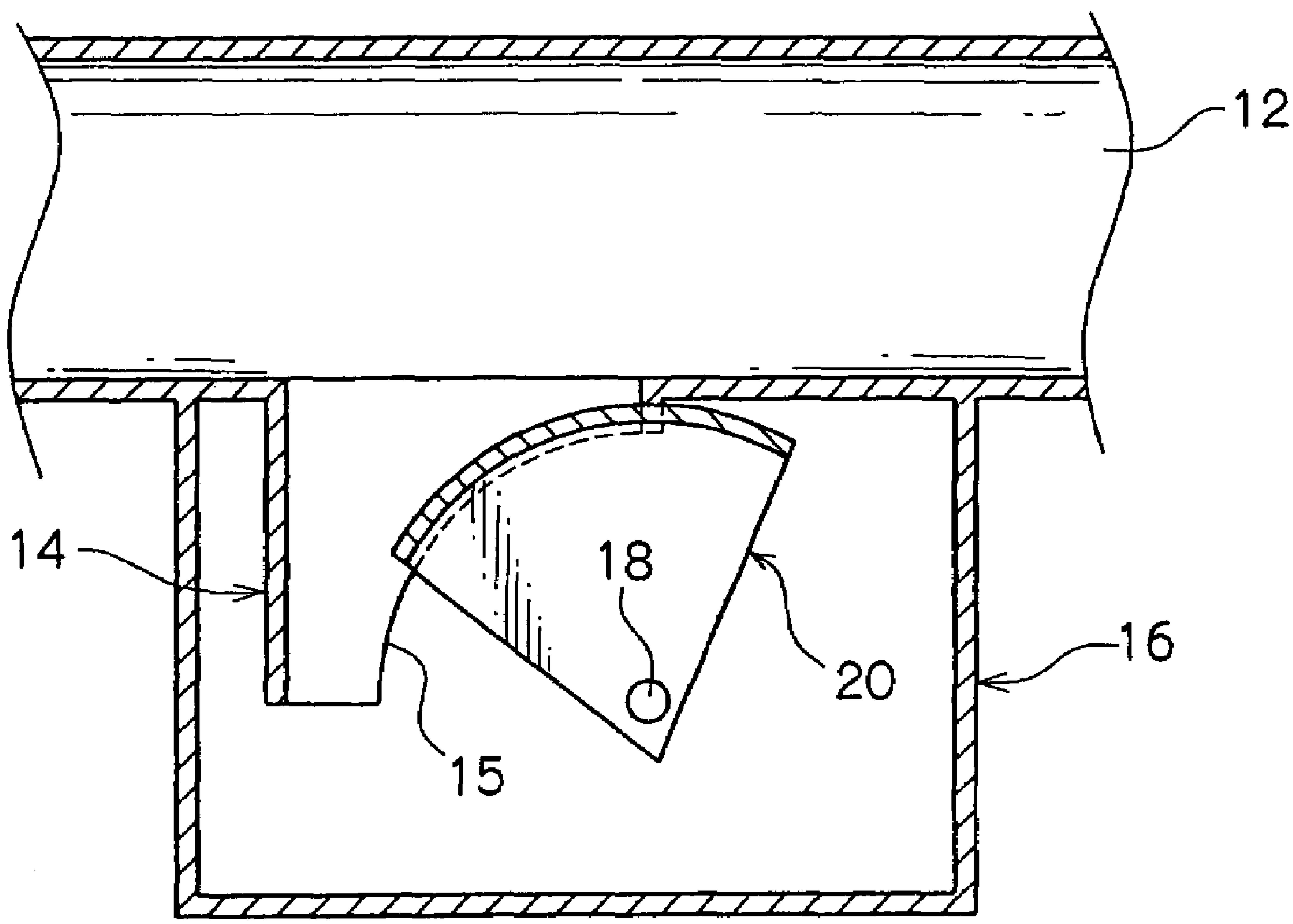


FIG.6

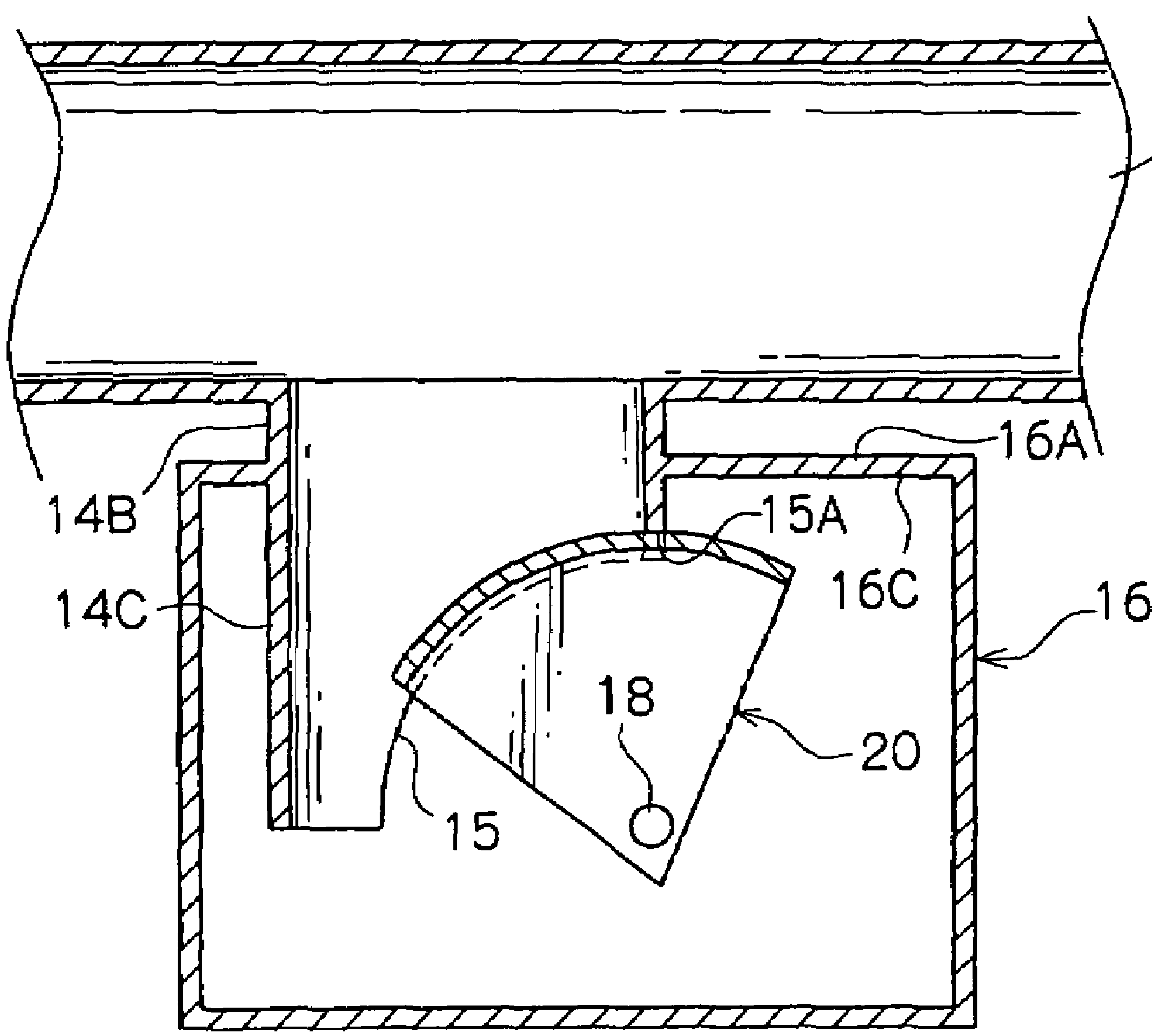


FIG.7

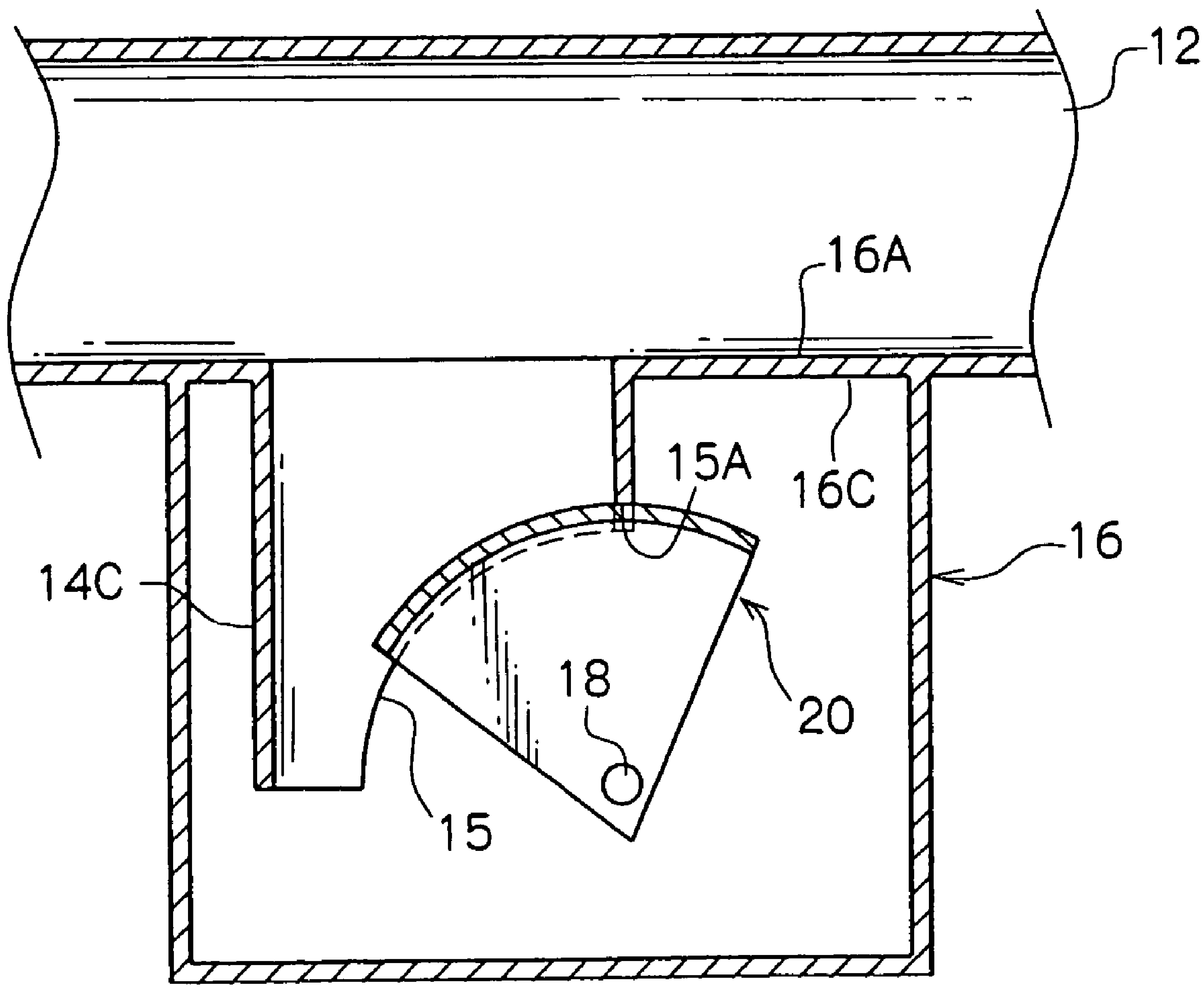


FIG.8A

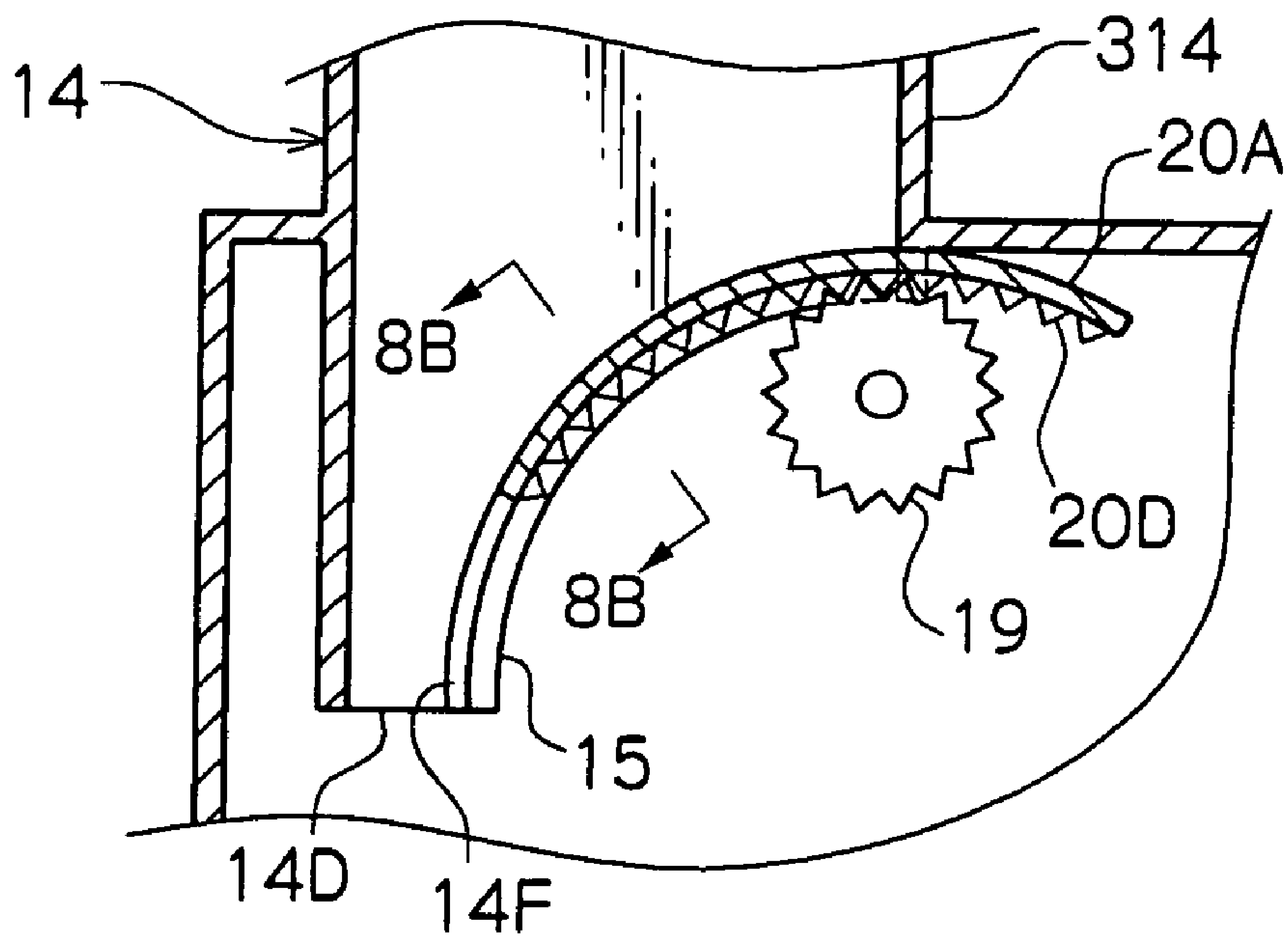


FIG.8B

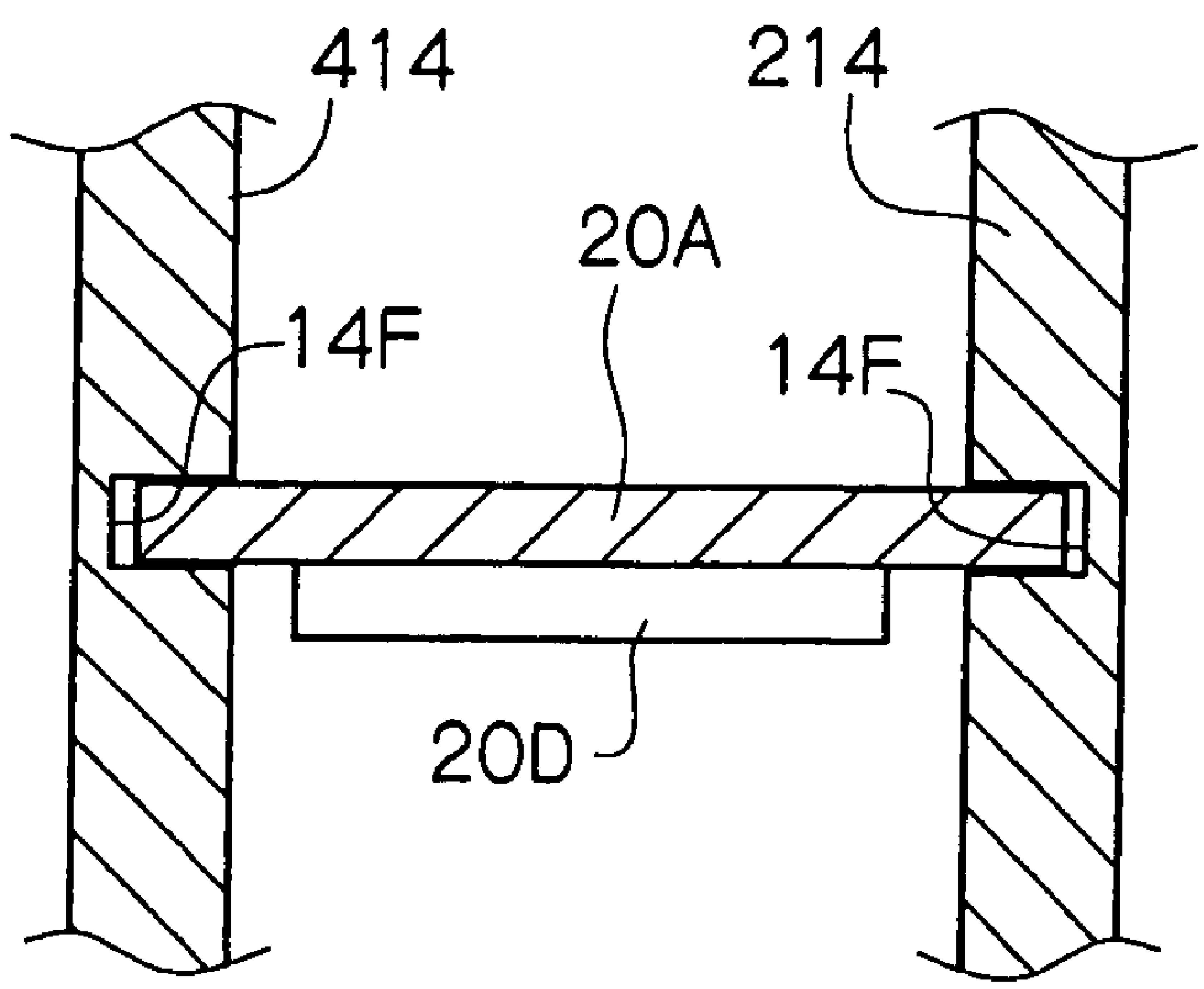


FIG.9

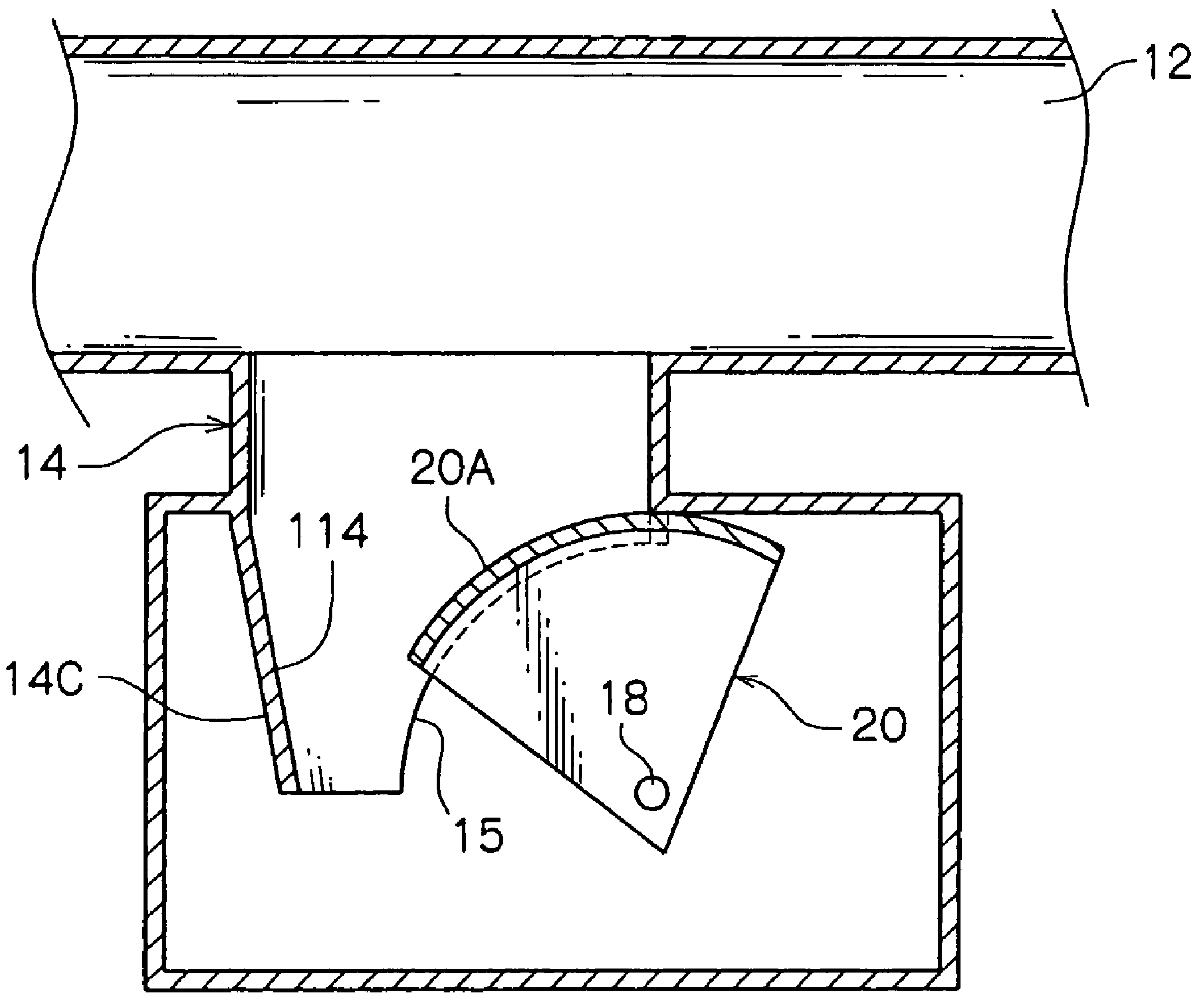


FIG.10

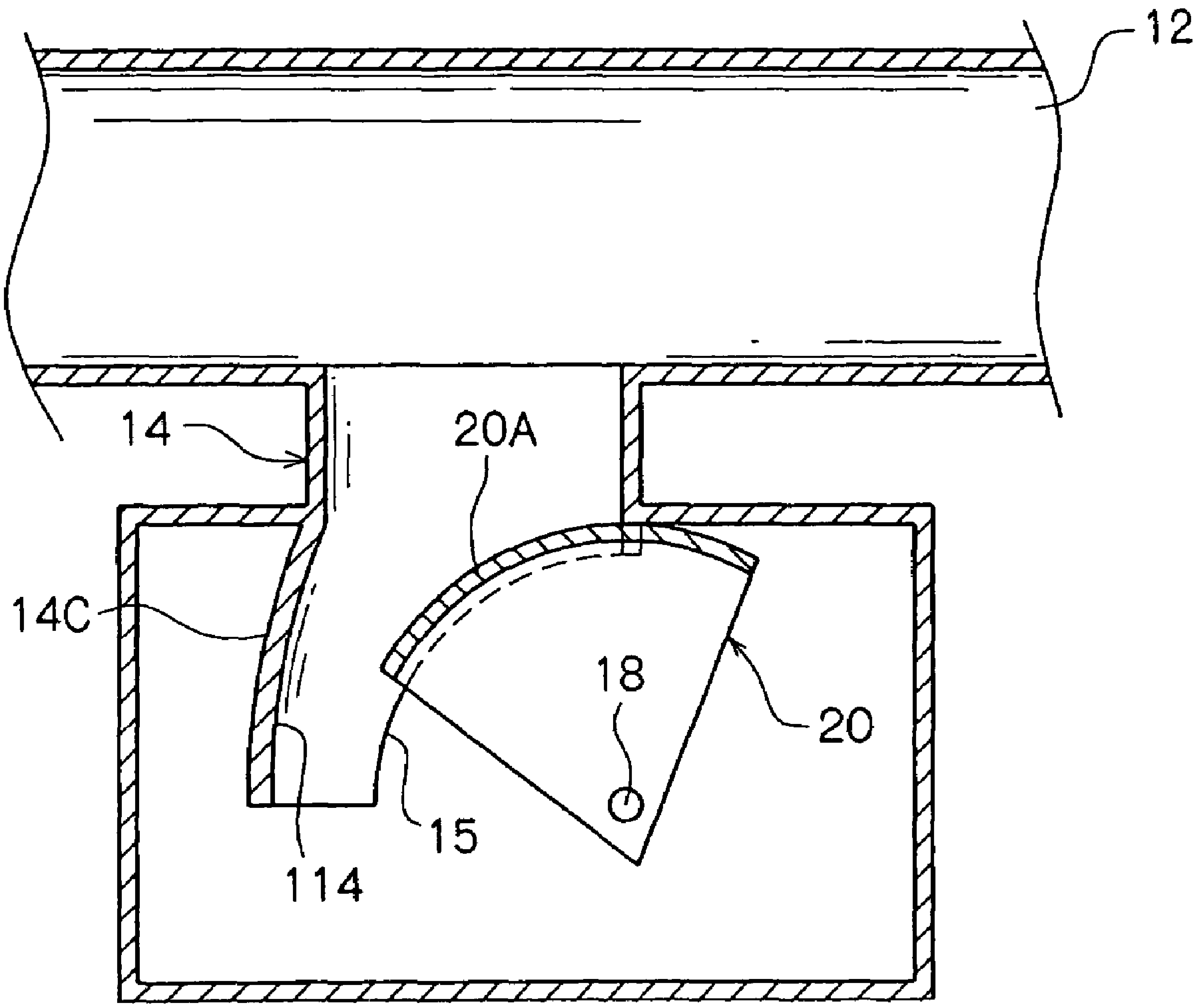


FIG.11A

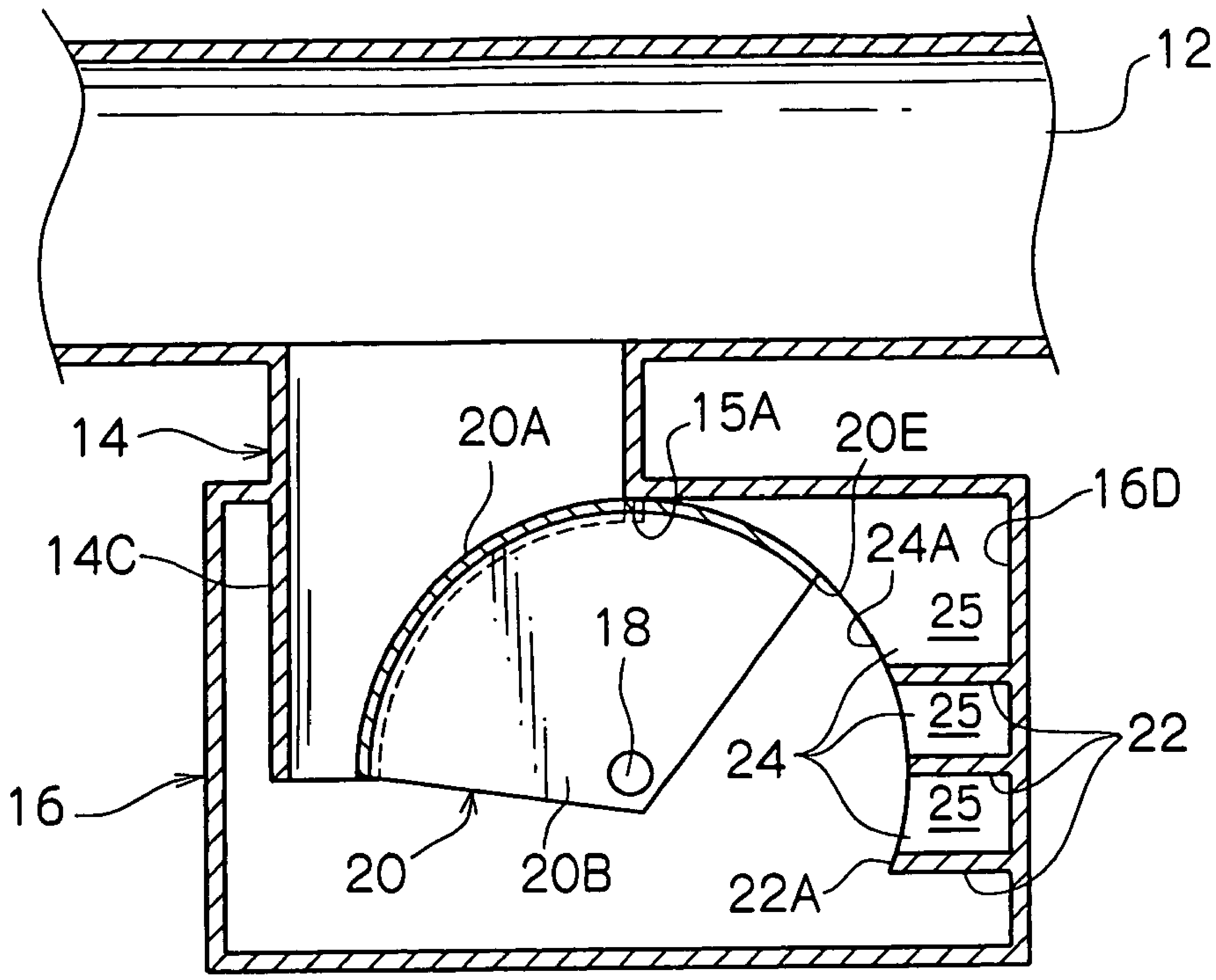


FIG.11B

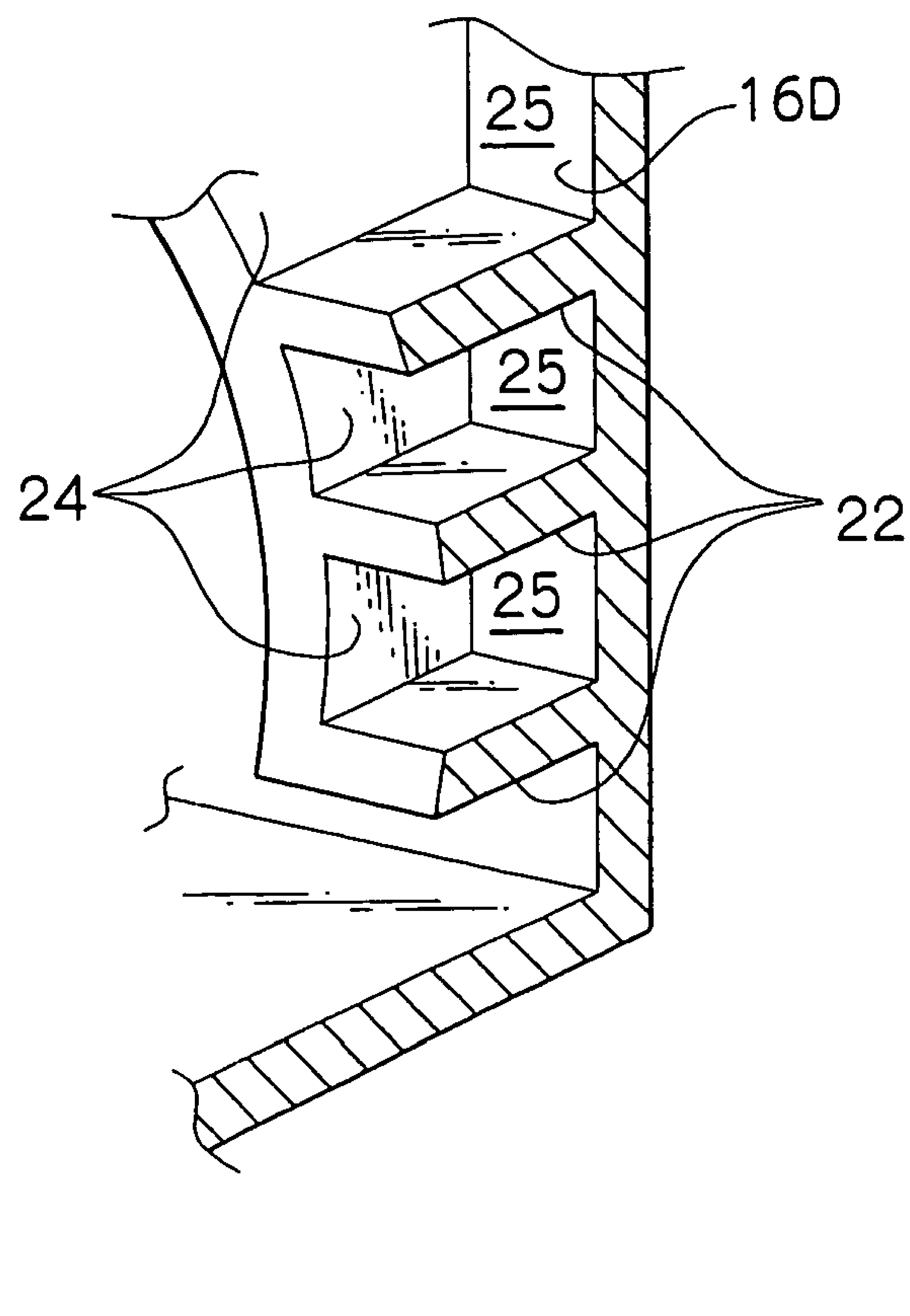


FIG.12

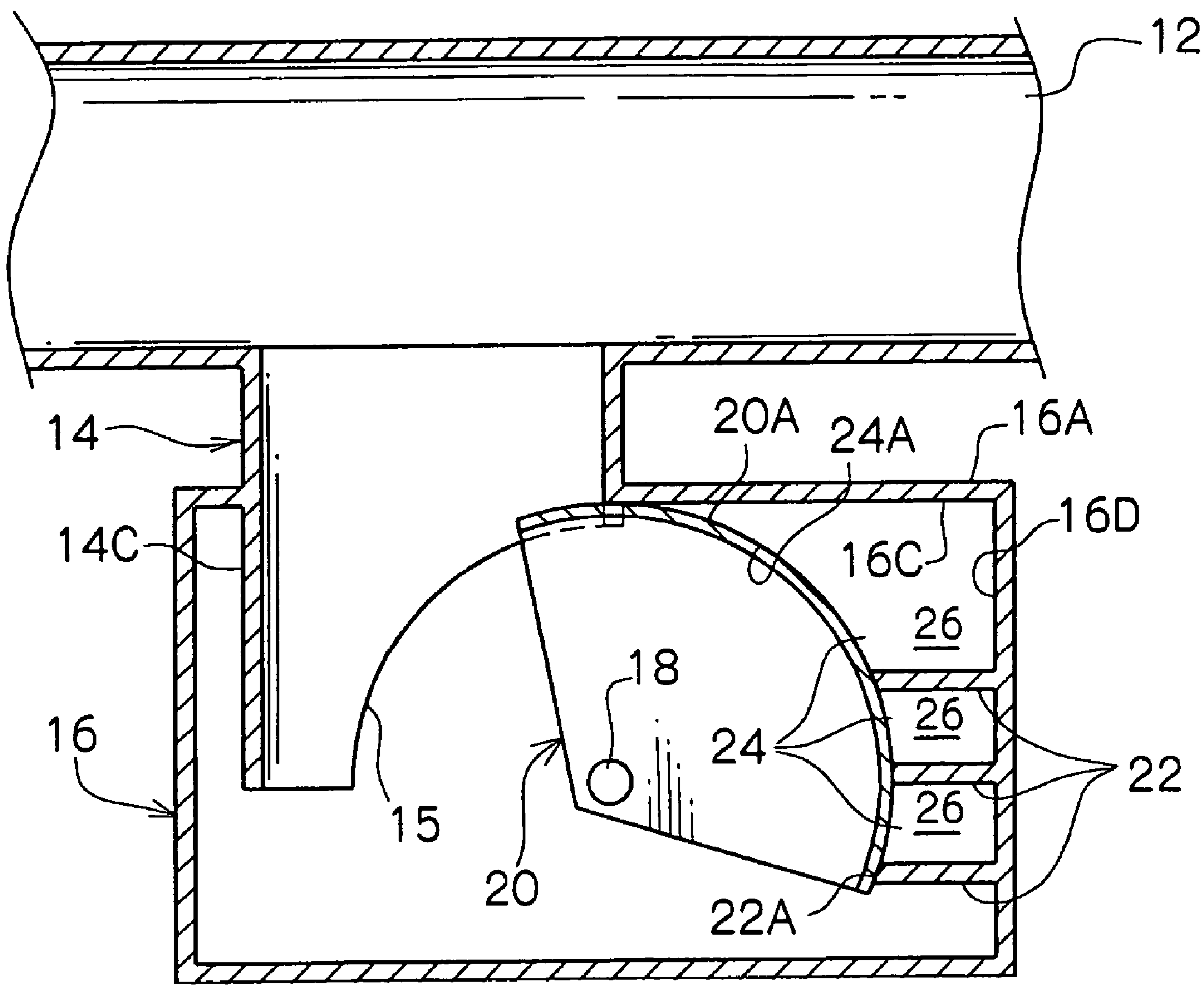


FIG.13

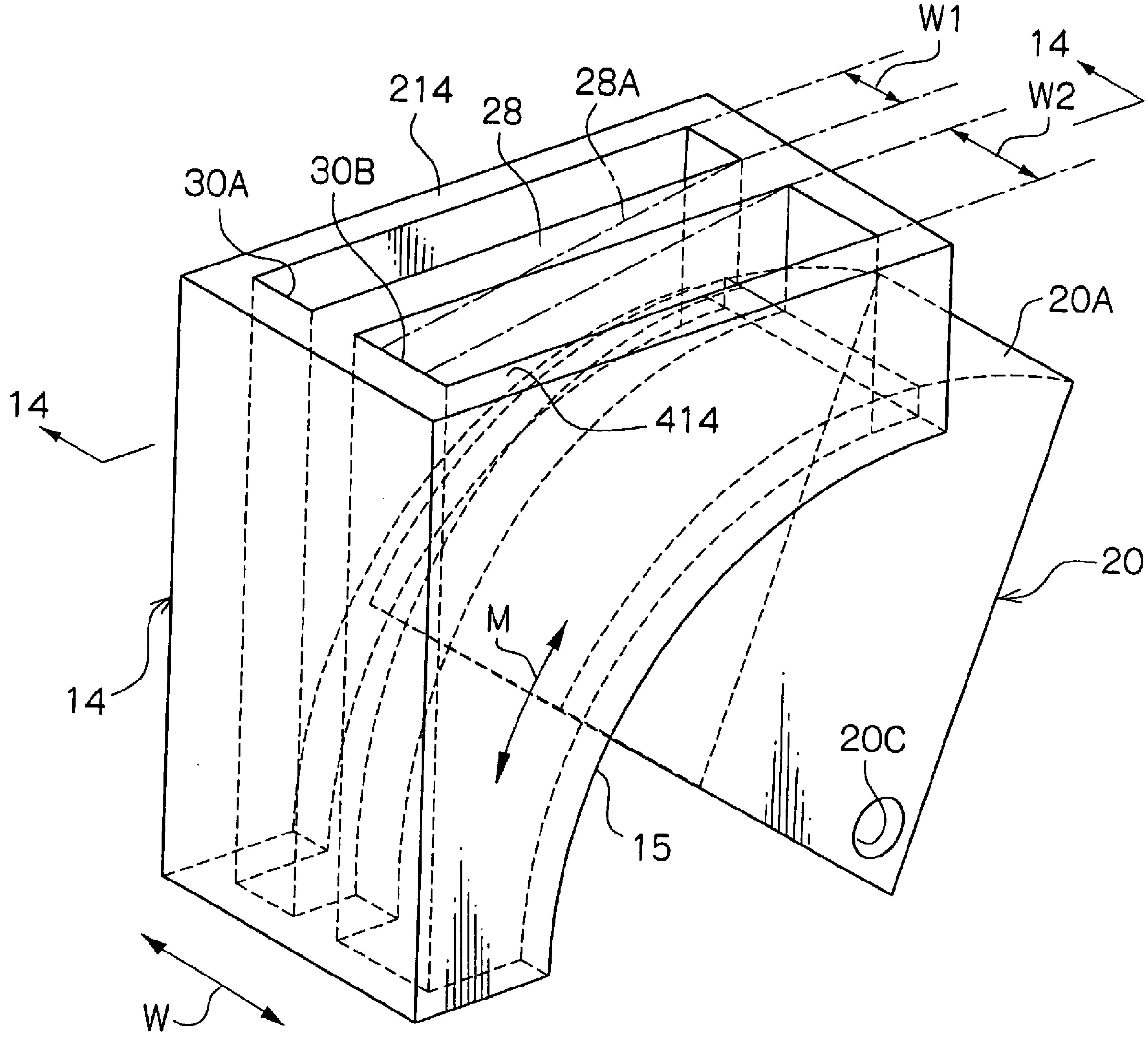


FIG.14

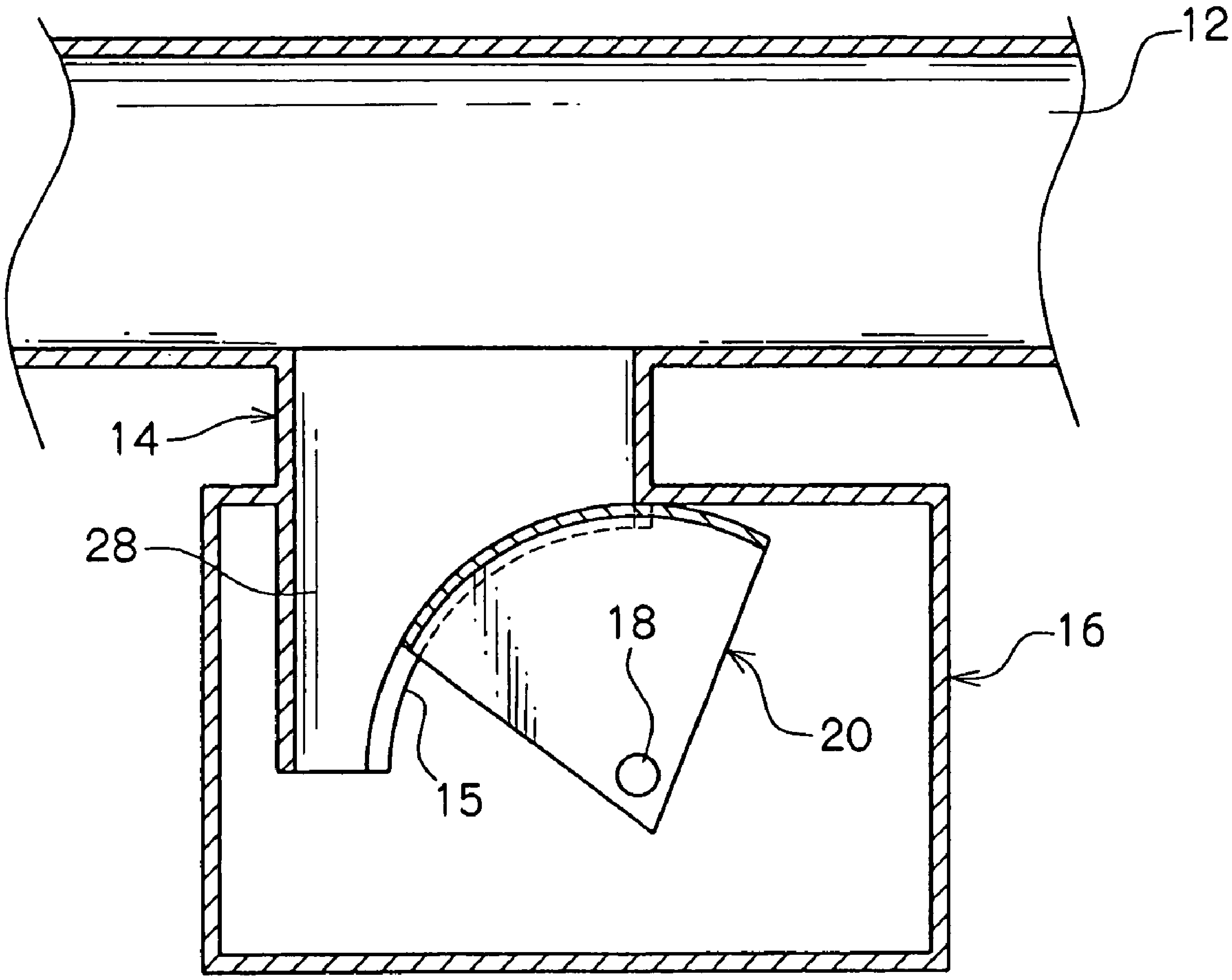


FIG.15A

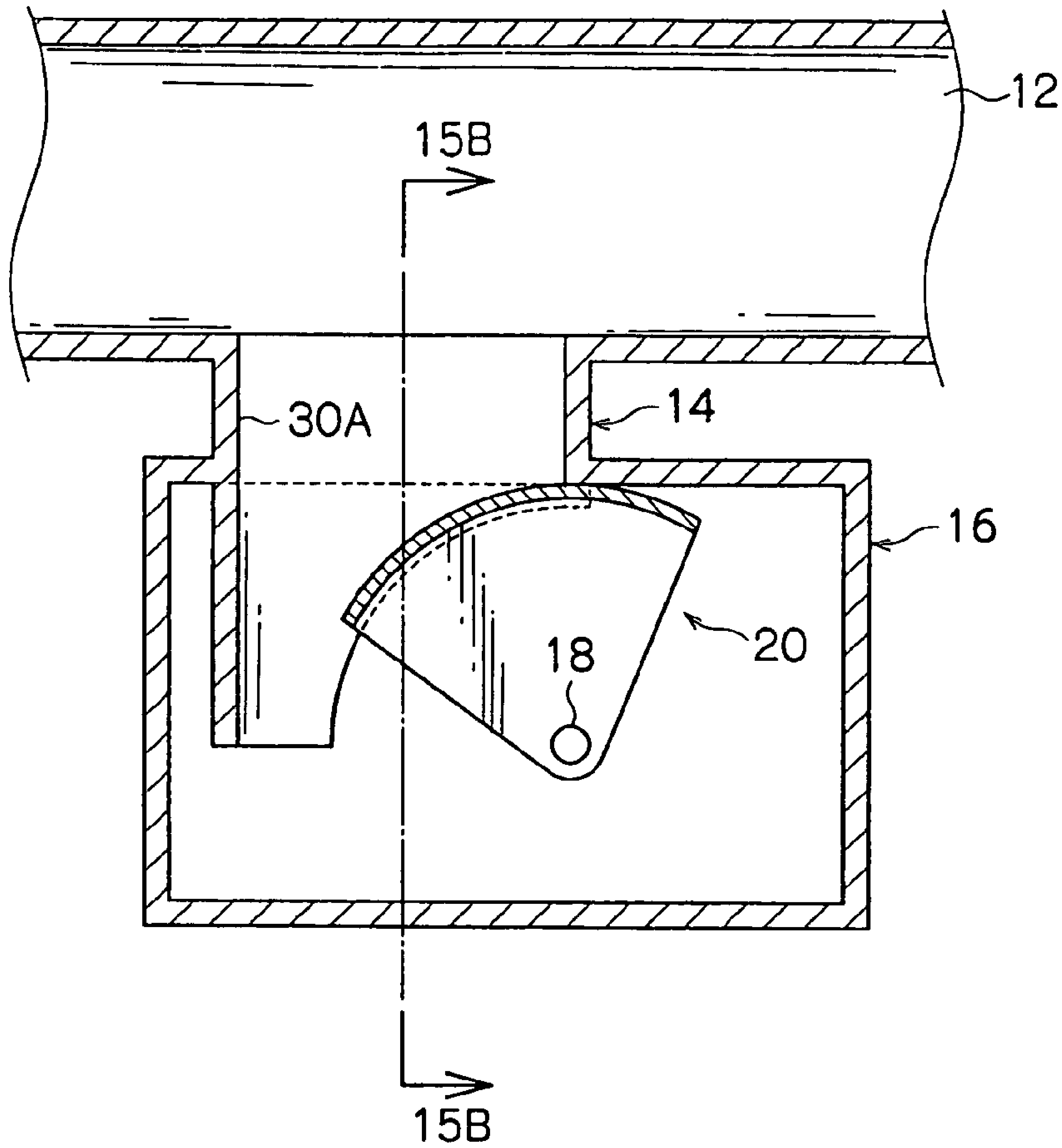


FIG.15B

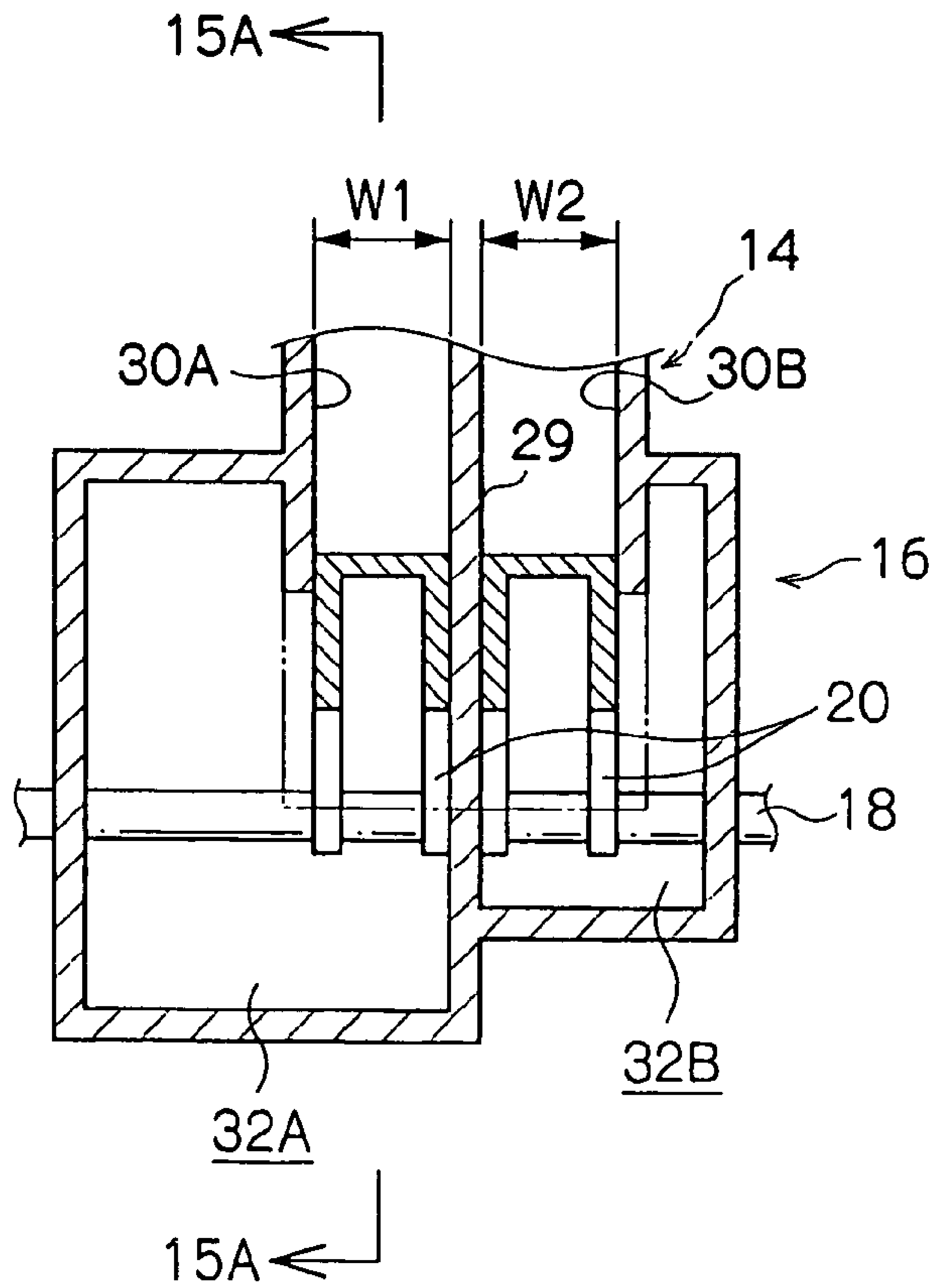


FIG.16A

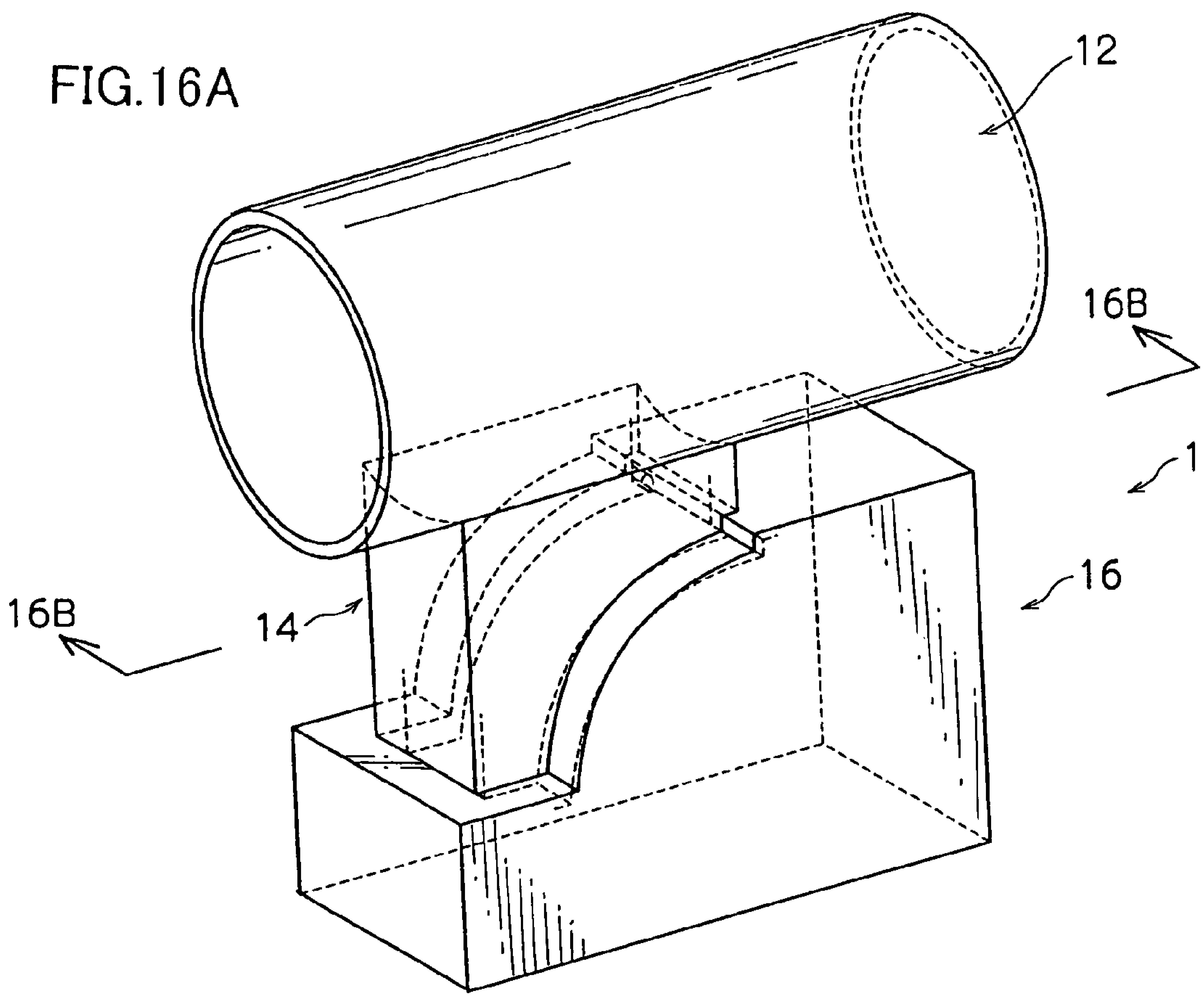
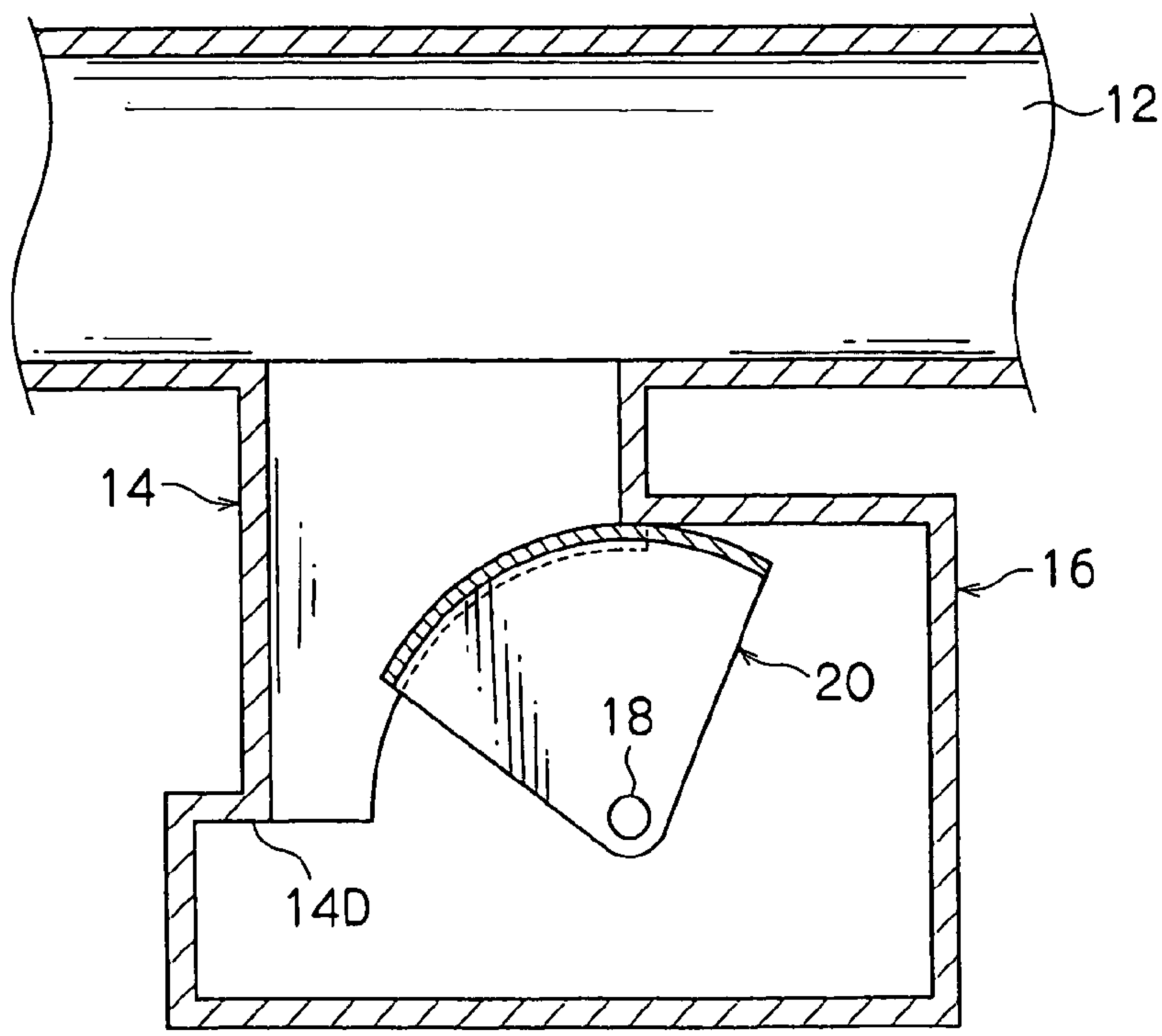


FIG.16B



MUFFLER

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority under 35USC 119 from Japanese Patent Application No. 2003-196620, the disclosure of which is incorporated by reference herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a muffler which reduces noise on an intake path or an exhaust path.

2. Description of the Related Art

Mufflers, which reduce noise by changing the resonance frequency in order to be able to reduce noises over a wide range of frequencies, are known.

For example, Japanese Utility Model Application Laid-Open (JP-U) No. 6-58151 discloses a muffler in which a movable wall, which is freely rotatable, is accommodated within a resonance box having a substantially cylindrical peripheral wall. Due to a partitioning plate of the movable wall slidably abutting the inner peripheral surface of the peripheral wall of the resonance box and rotating the movable wall, the length and the like of a neck portion, which is sectioned off and formed by the peripheral wall of the resonance box and the movable wall, is changed.

In such a muffler, the arc-shaped configuration of the inner peripheral surface of the peripheral wall of the resonance box, which configuration corresponds to the length from the center of rotation of the movable wall to the end portion of the partitioning plate, must be formed highly accurately.

Further, this structure presupposes that the end plate (side surface) of the movable wall also contacts the inner surface of the resonance box slidably and airtightly. Therefore, a highly accurate planar surface must be formed over a wide range in correspondence with the inner surface of the resonance box.

SUMMARY OF THE INVENTION

In view of the aforementioned, an object of the present invention is to provide a muffler which, with a simple structure, can reduce noises over a wide frequency band.

In order to achieve the above-described object, in accordance with one aspect of the present invention, there is provided a muffler attached to a path for intake and/or exhaust, comprising: a resonance box; a branch pipe shaped as a tube, and having a connecting portion at one side in a direction of a tube axis and a communicating portion at another side in the direction of the tube axis, and connecting the resonance box to the path, a free end of the connecting portion opening into the path, and an opening of a free end of the communicating portion being shaped as one of a curved surface and an inclined surface and opening into the resonance box; and a movable body able to gradually open and close the opening of the communicating portion.

Other objects, features and advantages of the present invention will be apparent to those skilled in the art from the explanation of the preferred embodiments of the present invention illustrated in the appended drawings, and from the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a muffler relating to a first embodiment of the present invention.

FIG. **2** is a sectional view taken along line **2-2** of FIG. **1**.

FIG. **3** is a sectional view showing a state in which a movable body has been rotated from the state of FIG. **2**.

FIG. **4** is an enlarged perspective view showing a branch pipe and the movable body relating to the first embodiment, where the branch pipe is shown with the upper portion thereof cut and in half-section, and the illustration of the relationship of the connection with a resonance chamber is omitted.

FIG. **5** is a sectional view of a muffler relating to a second embodiment of the present invention.

FIG. **6** is a sectional view of a muffler relating to a third embodiment of the present invention, which is equipped with a connecting portion.

FIG. **7** is a sectional view of a variant example of the muffler, where an intake duct is directly connected to a resonance box.

FIGS. **8**A and **8**B are drawings showing a muffler relating to a fourth embodiment of the present invention, where FIG. **8**A is a sectional view showing a driving section of an arc-shaped plate, and FIG. **8**B is a sectional view taken along line **8**B-**8**B of FIG. **8**A and showing a state in which the arc-shaped plate is inserted into guide-shaped groove portions.

FIG. **9** is a sectional view of a muffler relating to a fifth embodiment of the present invention.

FIG. **10** is a sectional view of a muffler relating to a sixth embodiment of the present invention.

FIGS. **11**A and **11**B are drawings showing a muffler relating to a seventh embodiment of the present invention, where FIG. **11**A is a sectional view showing a state in which a distal end portion of an arc-shaped plate has reached a distal end position of a communicating portion, and FIG. **11**B is a sectional perspective view showing auxiliary chambers.

FIG. **12** is a sectional view showing a movable body rotated in a cut-out portion opening direction, in the muffler relating to the seventh embodiment.

FIG. **13** is an enlarged perspective view showing a branch pipe and a movable body of a muffler relating to an eighth embodiment of the present invention.

FIG. **14** is a sectional view taken along line **14-14** of FIG. **13**.

FIGS. **15**A and **15**B are drawings showing a muffler relating to a ninth embodiment of the present invention, where FIG. **15**A is a sectional view taken along line **15**A-**15**A of FIG. **15**B, and FIG. **15**B is a sectional view taken along line **15**B-**15**B of FIG. **15**A.

FIG. **16**A is a perspective view showing a muffler relating to a tenth embodiment of the present invention in which a distal end of a branch pipe is connected to a resonance box, and FIG. **16**B is a sectional view taken along line **16**B-**16**B of FIG. **16**A.

DETAILED DESCRIPTION OF THE INVENTION

Plural embodiments will be described hereinafter, and parts and portions thereof which are common thereto (or which can be used in common) are denoted by the same reference numerals, and repeat description will be appropriately omitted.

Hereinafter, a muffler relating to a first embodiment of the present invention will be described in detail with reference to FIGS. **1** through **4**.

As shown in FIG. **1**, a muffler **10** is mounted to an intake duct **12** for an engine. However, the muffler **10** can be mounted to any arbitrary position from an air inlet of the unillustrated engine to an intake manifold.

The intake duct **12** is a tube whose cross-section is substantially circular. One end side **12**A thereof is connected to the engine, whereas another end side **12**B thereof is connected to an air cleaner. A branch pipe **14** has a substantially rectangular columnar configuration in which four side walls **114**, **214**, **314**, **414** are connected together at right angles.

A proximal end portion **14**A, which is one side of the branch pipe **14**, is connected to the intermediate portion of the intake duct **12**, such that the axial center of the branch pipe (tube axis AX) is vertical (see FIG. **2**). A resonance box **16** structuring a resonance chamber is connected to the other side of the branch pipe **14**. In this way, a connecting portion **14**B is formed between the intake duct **12** and the resonance box **16**.

A communicating portion **14**C at the lower side of the branch pipe **14** is set in the resonance box **16**, and a distal end **14**D opens within the resonance box **16**. The communicating portion **14**C has an arc-shaped cut-out portion **15** which is formed from the intermediate portion in the direction (the vertical direction) along the tube axis AX (see FIG. **2**) of the right-side side wall **314** in FIG. **4**, to the distal ends of the side walls **214**, **414**. The branch pipe **14** communicates with the interior of the resonance box via the distal end **14**D and the cut-out portion **15**.

An introduction cut-out **15**A which is substantially rectangular is formed in the central portion in the transverse direction (the direction of arrow W) of the branch pipe **14**, at the lower end of the side wall **314** of the cut-out portion **15**. The bottom surface (peak surface) of the introduction cut-out **15**A of the bottom end portion (the distal end portion) of the side wall **314** is in the same plane as a bottom surface **16**C of a top plate **16**A of the resonance box **16** (see FIG. **2**). A widthwise dimension WA of the introduction cut-out **15**A is equal to a widthwise dimension WB of the opposing portion of an inner surface portion **14**E of the branch pipe **14** (see FIG. **4**).

The resonance box **16** has a substantially parallelepiped exterior of a size which surrounds the communicating portion **14**C with an interval between the resonance box **16** and the outer periphery of the communicating portion **14**C. The resonance box **16** has a rotating shaft **18** which extends parallel to the top plate **16**A of the resonance box **16**, in a direction orthogonal to the longitudinal direction of the intake duct **12** (i.e., in the direction of arrow W).

The rotating shaft **18** is supported so as to be rotatable with respect to the resonance box **16**. One end of the rotating shaft **18** extends out from a through hole **16**B formed in the resonance box **16**, and is connected to a driving device formed by gears, a motor, and the like, such that the rotating shaft **18** can be driven and rotated.

A movable body **20** is provided at the interior of the resonance box **16**. The movable body **20** is basically structured from a pair of fan-shaped plates **20**B which are parallel to one another, and an arc-shaped plate **20**A which connects the arc-shaped outer peripheral portions of these fan-shaped plates **20**B. The fan-shaped plates **20**B have a fan-shape whose central angle is 70° to 80°. It is preferable that the arc-shaped plate **20**A and the fan-shaped plates **20**B of the movable body **20** be molded integrally.

As can be understood well from FIG. **4**, through-holes **20**C are formed at opposing positions of the both fan-shaped plates **20**B. The rotating shaft **18** is inserted through and fixed in these through-holes **20**C. Accordingly, the rotating shaft **18** and the movable body **20** can rotate integrally.

The outer peripheral wall of the arc-shaped plate **20**A is an arc-shaped surface whose center is the axial center of the rotating shaft **18**. The center of the arc of the cut-out portion **15** substantially coincides with the axial center of the rotating shaft **18**. Accordingly, when the rotating shaft **18** rotates, the outer peripheral surface of the arc-shaped plate **20**A can slide along and contact the bottom surface of the introduction cut-out **15**A (see FIG. **2**).

Note that a sealing material for sealing the sliding portions of the cut-out portion **15** and the movable body **20** can be provided. Any of various methods of fixing such as press-fitting, adhesion, a key and key groove structure, and the like, can be used in order to fix the rotating shaft **18** to the movable body **20**.

The distal end arc-shaped portions of the fan-shaped plates **20**B of the movable body **20** contact the opposing walls of the branch pipe side walls **214**, **414** (see FIG. **4**). When the movable body **20** rotates, the surface of the arc-shaped plate **20**A and the fan-shaped plates **20**B slide along the floor surface and the inner side surfaces of the introduction cut-out **15**A (see FIG. **4**), and the fan-shaped plates **20**B slide along the opposing surfaces of the side walls **214**, **414** at the peripheral portion of a cut-out portion opening portion **15**B (see FIG. **4**). A sealing material can be provided at these sliding portions.

As shown in FIG. **3**, as the arc-shaped plate **20**A gradually closes the cut-out portion **15**, a length L of a neck portion which connects the intake duct **12** and the resonance box **16** (i.e., a portion generally called the communicating pipe of the resonator) becomes longer, and a cross-sectional surface area S of the opening of the distal end portion (the lower end portion) of the neck portion becomes smaller. Accordingly, the resonance frequency can be varied in accordance with the position of the movable body **20**. The neck portion is structured by the inner walls of the connecting portion **14**B and the communicating portion **14**C, and the outer periphery of the arc-shaped plate **20**A.

Note that the rotating shaft **18** and the fan-shaped plates **20**B can be molded integrally. Further, the fan-shaped plates **20**B can be made to be lighter-weight by forming one or more through holes therein within a range in which the strength thereof during usage can be ensured.

Operation of the first embodiment will be described hereinafter.

Sound waves of the intake duct **12** enter into and are received in the resonance box **16** via the branch pipe **14**. At the branch pipe **14**, the movable body **20** is disposed slidably at the peripheral portion of the opening of the cut-out portion **15**. Due to the rotation of the movable body **20**, the range of opening/closing of the cut-out portion **15** is changed. The lengthwise direction dimension (i.e., the length) L of the neck portion formed by the branch pipe **14** and the arc-shaped plate **20**A, and the lateral cross-sectional surface area S of the distal end of the neck portion can be changed continuously (not in a stepwise manner).

FIG. **3** illustrates a state in which the movable body **20** has been rotated further in the counterclockwise direction from the state shown in FIG. **2**, and closes the entire cut-out portion **15**. The final end portion (the clockwise direction end portion) of the arc-shaped plate **20**A abuts the introduction cut-out **15**A, and the lengthwise direction dimension L of the neck portion formed by the branch pipe **14** and the arc-shaped plate **20**A is at its longest. Further, the amount by which the arc-shaped plate **20**A engages with the side wall **114** of the communicating portion **14**C is a maximum, and the lateral cross-sectional surface area S of the distal end of the neck portion is the most reduced.

In this way, in accordance with the rotation of the movable body **20** in the counterclockwise direction, the length L of the neck portion becomes longer, and the lateral cross-sectional surface area S of the distal end of the neck portion becomes smaller. On the other hand, in accordance with the rotation of the movable body **20** in the clockwise direction, the length L of the neck portion becomes shorter, and the lateral cross-sectional surface area S of the distal end of the neck portion increases.

Here, the noise frequency of the intake noise or the like is detected, and, in order to become a predetermined resonance frequency which corresponds to the detected frequency, control is carried out such that an operation signal is transmitted to an unillustrated driving means such as a motor or the like, and the movable body **20** within the resonance box **16** rotates to the needed rotational angle position.

In this way, noises of a frequency band of a wide width can be reduced simply and extremely effectively.

The resonance box **16** and the movable body **20** can be structured by relatively small, inexpensive parts. Further, common usage of parts is easy.

FIG. **5** illustrates a muffler relating to a second embodiment of the present invention.

The second embodiment differs from the first embodiment in which the annular connecting portion **14**B is formed between the intake duct **12** and the resonance box **16**. In the second embodiment, such an annular connecting portion does not exist, and the intake duct **12** is directly connected to the resonance box **16**.

FIG. **6** illustrates a muffler relating to a third embodiment of the present invention.

In the third embodiment, the floor surface of the introduction cut-out **15**A is positioned at a position which is further in the resonance box **16** than the bottom surface **16**C of the top plate **16**A of the resonance box **16**.

FIG. **7** illustrates a modified example of the third embodiment.

In this modified example, the resonance box is directly connected to the intake duct. Namely, the portion corresponding to the connecting portion **14**B in the third embodiment does not exist.

FIGS. **8**A and **8**B illustrate a muffler relating to a fourth embodiment of the present invention.

In the fourth embodiment, guide-shaped groove portions **14**F, which are arc-shaped and oppose one another, are formed in a vicinity of the cut-out portion **15** of the branch pipe **14**. The arc-shaped plate **20**A is guided by the groove portions **14**F, and can move along the peripheral portion of the opening of the cut-out portion **15**. In order to drive the arc-shaped plate **20**A, an internal-toothed gear **20**D is provided at the inner side of the arc-shaped plate **20**A, and a gear **19**, which is connected to an unillustrated motor or the like, meshes together with the internal-toothed gear **20**D.

Note that the guide-shaped groove portions and the arc-shaped plate can be made to be rectilinear rather than arc-shaped, and can be structured so as to incline from the upper right to the lower left of FIG. **8**A, i.e., from the intermediate portion of the side wall **314** to the distal end **14**D. In the embodiments which have been described heretofore and which will be described hereinafter, this structure of a movable body which can move rectilinearly at an incline in this way can be employed.

FIG. **9** illustrates a muffler relating to a fifth embodiment of the present invention.

In the fifth embodiment, the side wall **114** of the communicating portion **14**C approaches the movable body **20** as the side wall **114** extends toward the distal end side thereof (the lower side in the drawing). In this structure, the lateral cross-sectional surface area of the neck portion structured from the branch pipe **14** and the arc-shaped plate **20**A can be varied even more greatly by the operation (the rotation) of the arc-shaped plate **20**A.

FIG. **10** illustrates a muffler relating to a sixth embodiment of the present invention.

In the sixth embodiment, the side wall **114** of the communicating portion **14**C moves away from the movable body **20** as the side wall **114** extends toward the distal end side thereof (the lower side in the drawing). Accordingly, the lateral cross-sectional surface area of the neck portion can be varied gradually and continuously by the operation (the rotation) of the arc-shaped plate **20**A. This is effective in cases in which different frequency characteristics are obtained by using the movable body **20** in common.

FIGS. **11**A, **11**B and **12** illustrate a muffler relating to a seventh embodiment of the present invention.

In the seventh embodiment, in addition to varying the length of the neck portion and the lateral cross-sectional surface area of the distal end of the neck portion, the volume of the interior of the resonance box **16** also is varied.

FIG. **11**A illustrates a state in which the distal end portion of the arc-shaped plate **20**A (the left side end portion in the drawing) has reached the position of the distal end of the communicating portion **14**C (the position at the lowermost end in the drawing). The portion of the arc-shaped plate **20**A, at which portion the cross-section is arc-shaped, is long as compared with that in the first embodiment (see FIG. **3**), and the fan-shaped plates **20**B at the both sides of the arc-shaped plate **20**A have fan-shapes whose central angles are obtuse angles.

Within the resonance box **16**, a plurality of (three in the present embodiment) lateral ribs **22** serving as sectioning wall portions are formed at an inner wall surface **16**D which extends substantially orthogonally to the axial center of the intake duct **12**.

The lateral ribs **22** project substantially orthogonally from the inner wall surface **16**D, and extend in a direction which is orthogonal to the surface of the drawing of FIG. **11**A. The widths of the lateral ribs **22** (their lengths in the direction orthogonal to the surface of the drawing of FIG. **11**A (the direction of arrow W in FIG. **1**)) are the same as or shorter than the width of the arc-shaped plate **20**A (the length of the arc-shaped plate **20**A in the above-described direction).

As shown in FIG. **11**B, the both side portions of the three lateral ribs **22** are connected by vertical ribs **24**. The vertical ribs **24** project substantially orthogonally from the inner wall surface **16**D.

Respective auxiliary chambers **25**, which are sectioned off and formed by the lateral ribs **22** and the vertical ribs **24** for the most part, communicate with the interior of the resonance box **16** at the distal end sides of the ribs.

The projecting lengths (heights) of the lateral ribs **22** and the vertical ribs **24** are set such that the respective distal ends of the lateral ribs **22** and the vertical ribs **24** slidingly contact the arc-shaped plate **20**A of the movable body **20** which is rotating.

Further, peak portions **22**A of the lateral ribs **22** and peak portions **24**A of the vertical ribs **24** have arc-shaped configurations which correspond to the configuration of the arc-shaped plate **20**A such that the airtight quality between the arc-shaped plate **20**A and the peak portions **22**A, **24**A can be maintained when the peak portions **22**A, **24**A are abutting the arc-shaped plate **20**A.

FIG. **12** illustrates a state in which the movable body **20** has rotated in the direction of opening the cut-out portion **15** (the clockwise direction). When the movable body **20** rotates to this position, several (three in the drawing) airtight spaces (the auxiliary chambers **25**), which are sectioned-off and formed (sealed) by the arc-shaped plate **20**A, the lateral ribs **22**, the vertical ribs **24**, the inner wall surface **16**D, the bottom surface **16**C of the top plate **16**A, and the like, are formed. A volume V of the interior of the resonance box **16** is thereby substantially reduced.

Because the portion of the arc-shaped plate **20**A where the cross-section thereof is arc-shaped is long, it is effective in varying the volume V. Note that a structure can be formed in which the change in the volume V is made gradual by providing even more of the lateral ribs **22** and fractionalizing the spaces which can be sealed (the auxiliary chambers).

As described above, in the seventh embodiment, when the rotating body **20** rotates in the direction of opening the cut-out portion **15** (the clockwise direction), the volume V of the interior of the resonance box **16** is substantially reduced in accordance therewith. On the other hand, when the rotating body **20** rotates in the direction of closing the cut-out portion **15** (the counterclockwise direction), the volume V of the interior of the resonance box **16** is substantially increased in accordance therewith. In this way, the three factors which can change the resonance frequency, i.e., (1) the length of the neck portion, (2) the lateral cross-sectional surface area of the distal end of the neck portion, and (3) the volume of the interior of the resonance box **16**, can be varied.

Note that the vertical ribs **24** can be rendered useless in a case in which a widthwise dimension WD of the arc-shaped plate **20**A (see FIG. **4**) and the widthwise dimension of the inner wall surface of the resonance box **16** (the length in the direction orthogonal to the surface of the drawing of FIG. **12**: the length in the direction of arrow W in FIG. **1**) are equal.

FIGS. **13** and **14** illustrate a muffler relating to an eighth embodiment of the present invention.

In the eighth embodiment, a partitioning wall **28** is formed so as to follow along the moving direction of the movable body **20**, between the side walls **214**, **414** of the branch pipe **14** which are the two surfaces which oppose one another in the widthwise direction (the direction of arrow W). The partitioning wall **28** partitions a pass-through portion **14**E of the branch pipe **14** (see FIG. **4**) into two, and is disposed parallel to the side walls **214**, **414**.

A first through path **30**A and a second through path **30**B, which have been separated by the partitioning plate **28**, form, together with the arc-shaped plate **20**A, respectively independent neck portions. A widthwise dimension W1 of the first through path **30**A and a widthwise dimension W2 of the second through path **30**B are not equal (W1≠W2).

Because the cross-sectional surface areas of the neck portions are different, noises of two frequency components can simultaneously be reduced.

In the intake noise generated by the intake pulsation of the engine, the noise level of a specific frequency corresponding to the engine speed becomes large. For example, a frequency F (Hz) of the noise at a 4-cycle engine is expressed by following formula 1, where the engine speed is R (rpm) and the number of cylinders is s.

$$F=(1/2)\times R\times(1/60)\times s\times n \tag{1}$$

Here, n=1, 2, 3, . . .

The main components of the intake noise generated at, for example, 3000 rpm in a four-cylinder engine include 100 Hz (first order of engine combustion (or explosion first-degree component)), 200 Hz (second order of engine combustion (or explosion second-degree component)), 300 Hz (third order of engine combustion (or explosion third-degree component)), . . .

The present muffler functions as a resonator-type muffler. A resonator resonance frequency f (Hz) is expressed by following formula 2, where the lateral cross-sectional surface area of the neck portion (the communicating pipe) is S (cm^2), the length of the neck portion (the communicating pipe) is L (cm), and the volume is V (cc).

$$f=(C/2\pi)\times[\sqrt{\{S/(L\times V)\}}] \tag{2}$$

Here, C=34,000 cm/s (sound speed).

When the widthwise dimension W1 of the first through path **30**A and the widthwise dimension W2 of the second through path **30**B are set, if the partitioning wall **28** is structured and disposed such that, for example, W1:W2=1:4, the noises of the 1:2 frequency components can be reduced simultaneously. If the other configurations and dimensions are set appropriately, the noises of the first order and the second order of engine combustion can be reduced simultaneously. Similarly, if the partitioning wall **28** is disposed such that W1:W2=1:9, the first order and the second order of engine combustion of the noise can be reduced simultaneously.

If the side walls **214**, **414** are not parallel to the partitioning wall **28**, the frequency ratio can be changed in accordance with the position and the state of abutment of the movable body **20** with respect to the cut-out portion **15** of the arc-shaped plate **20**A.

For example, if a partitioning wall **28**A is positioned as shown by the imaginary line in FIG. **13**, the widthwise dimension (W1) of the first through path **30**A at the side near the movable body **20** is narrow, and gradually becomes wider the further away from the movable body **20**. On the other hand, the widthwise dimension (W2) of the second through path **30**B at the side near the movable body **20** is wide, and gradually becomes more narrow the further away from the movable body **20**.

Accordingly, when the movable body **20** moves to close the cut-out portion (the opening portion) **15**, the decrements in the lateral cross-sectional surface areas (the opening portions) are respectively different at the first through path **30**A and the second through path **30**B. Namely, the decreased frequency ratio of the first through path **30**A and the second through path **30**B can change in accordance with the angle of rotation of the movable body **20**.

Note that two or more of the partitioning plates **28** can be provided. For example, if two partitioning plates **28** are provided and the ratio of the widthwise dimensions of the neck portion divided into three within the branch pipe **14** is set to be 1:4:9, the noises of the first order, the second order, and the third order of engine combustion can be reduced markedly. Namely, noises of a plurality of orders of engine combustion or noises of components of a plurality of degrees in a wide frequency band of the engine of a vehicle or the like can be reduced simultaneously.

In this way, noises of frequencies of desired ratios can be reduced simultaneously. Further, there is no need for a complex structure in order to rotate the movable body **20**. Rotating of the movable body **20** can be carried out simply by, for example, one motor (driving means), which is extremely practical and economical.

In order to vary the frequency ratio, a mechanism can be added which can change the ratio of the widthwise dimensions (W1:W2) of the neck portion which is divided by the partitioning wall **28** within the branch pipe **14**. Namely, for example, the partitioning wall **28** can be disposed so as to be movable in the widthwise direction (the direction of arrow W) within the branch pipe **14**, and can be moved in the widthwise direction (the direction of arrow W) by a driving means such as a motor or the like in accordance with the frequency for which a reduction is desired.

FIG. **15** illustrates a muffler relating to a ninth embodiment of the present invention.

In the ninth embodiment, the first through path **30**A and the second through path **30**B are connected to a respectively independent first resonance chamber **32**A and second resonance chamber **32**B, and noises of two frequency components can be reduced simultaneously.

The interior of the branch pipe **14** is partitioned by a partitioning wall **29**. The widthwise dimension W1 of the first through path **30**A and the widthwise dimension **30**B of the second through path **30**B are substantially the same. Accordingly, the first through path **30**A and the second through path **30**B have substantially the same lateral cross-sectional surface areas.

The partitioning wall **29** partitions the resonance box **16** by being set in the resonance box **16** such that the first resonance chamber **32**A and the second resonance chamber **32**B are formed.

Respective movable bodies **20**, **20** are disposed in the first resonance chamber **32**A and the second resonance chamber **32**B. The resonance bodies **20**, **20** are fixed to the one rotating shaft **18**, and can rotate together with the rotating shaft **18**. Note that a structure can be used in which the movable bodies **20**, **20** are fixed to separate rotating shafts and are operated independently of one another.

A volume V1 of the first resonance chamber **32**A and a volume V2 of a second resonance chamber **32**B are unequal ($V1 \neq V2$). By setting the volumes V1, V2 on the basis of formula (2) of the above-described eighth embodiment, noises of two desired frequency components can be reduced simultaneously.

Two or more of the partitioning walls **29** can be provided.

FIGS. **16**A and **16**B illustrate a muffler relating to a tenth embodiment of the present invention.

In the tenth embodiment, the majority of the branch pipe is exposed at the exterior of the resonance box. Namely, the distal end of the branch pipe is joined to the resonance box without the branch pipe being set in the resonance box.

The present invention is not limited to the above-described first through tenth embodiments, and various changes and modifications can be carried out.

For example, the resonance box may have a different container-like configuration, such as may be substantially cylindrical or the like.

Further, instead of the structure in which the surface of the arc-shaped plate and the fan-shaped plates slide at the peripheral portion of the opening of the cut-out portion, a structure in which only the surface of the arc-shaped plate slides thereat can be employed.

Moreover, in place of the structure in which the movable body is moved along the cut-out portion provided at the branch pipe, a structure can be employed in which the movable body is moved at the inner side of the branch pipe, without providing the cut-out portion. Or, instead of a structure provided with the cut-out portion, a structure in which one or more through-holes are provided in side walls can be used.

In addition, instead of connecting the muffler to the intake duct **12**, the muffler can be connected to, for example, an air cleaner or the like. Noise can be reduced in this way as well.

As described above, in accordance with the muffler of the present invention, noises over a wide frequency band can be effectively reduced by a simple structure.

What is claimed is:

1. A muffler attached to a path for intake and/or exhaust, comprising:

a resonance box;

a branch pipe shaped as a tube, and having a connecting portion at one side in a direction of a tube axis and a communicating portion at another side in the direction of the tube axis, and connecting the resonance box to the path, a free end of the connecting portion opening into the path, and an opening of a free end of the communicating portion being shaped as one of a curved surface and an inclined surface and opening into the resonance box; and

a movable body that gradually changes an opening area of the opening and an effective length of the branch pipe from a first state to a second state wherein the opening area is greater in the second state than in the first state and the effective length is greater in the first state than in the second state.

2. The muffler of claim **1**, wherein

the connecting portion of the branch pipe is exposed at an exterior of the resonance box, and

the communicating portion of the branch pipe is set within the resonance box.

3. The muffler of claim **1**, wherein a majority of the branch pipe is set within the resonance box.

4. The muffler of claim **1**, wherein the movable body includes a cylindrical surface which conforms to a configuration of the opening of the communicating portion in order to close the opening of the communicating portion, and the movable body swings around an axis of rotation which substantially includes a center of curvature of the cylindrical surface.

5. The muffler of claim **1**, wherein the movable body includes an arc-shaped plate having a cylindrical surface which conforms to a configuration of the opening of the communicating portion in order to close the opening of the communicating portion, and a pair of guide grooves guiding both sides of the arc-shaped plate, and a driving mechanism for driving the arc-shaped plate.

6. The muffler of claim **1**, wherein the communicating portion includes an inner surface which is inclined so as to gradually approach the tube axis, from a side opposite the free end toward the free end.

7. The muffler of claim **1**, wherein the communicating portion includes an inner surface which is curved so as to gradually move away from the tube axis, from a side opposite the free end toward the free end.

8. The muffler of claim **1**, wherein the resonance box includes one or more auxiliary chambers provided at an interior of the resonance box.

9. The muffler of claim **8**, wherein each of the auxiliary chambers has an opening which can be opened and closed by the movable body.

10. The muffler of claim **8**, wherein the auxiliary chambers are disposed along a direction of movement of the movable body.

11. The muffler of claim **1**, wherein the branch pipe includes at least one partitioning wall which extends along a direction of movement of the movable body and which divides an interior of the branch pipe into a plurality of through paths.

12. The muffler of claim **11**, wherein cross-sectional configurations of the through paths in a direction traversing the tube axis are the same.

13. The muffler of claim **11**, wherein cross-sectional configurations of the through paths in a direction traversing the tube axis are respectively different.

14. The muffler of claim **1**, wherein the muffler includes a partitioning wall which extends along a direction of movement of the movable body, and divides an interior of the branch pipe into two through paths, and divides the resonance box into two resonance chambers.

15. The muffler of claim **1**, wherein a majority of the branch pipe is exposed at an exterior of the resonance box.

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